DOCUMENT RESUME

ED 099 500 CE 002 577

TITLE	Module Three: Resistance; Basic Electricity and Electronics Individualized Learning System.
INSTITUTION	Bureau of Naval Personnel, Washington, D.C.
REPORT NO	NAVPERS-94558-3a
PUB DATE	Jan 72
NOTE	116p.; For other modules in the series, see CE 002 573-589
EDRS PRICE	MF-$0.75 HC-$5.40 PLUS POSTAGE
DESCRIPTORS	Course Content; *Electricity; *Electronics; Individualized Instruction; Individualized Programs; Industrial Education; Military Training; Post Secondary Education; *Programed Instruction; *Programed Materials; Study Guides; Trade and Industrial Education; Units of Study (Subject Fields)

ABSTRACT

In this module the student will learn of the opposition offered to electron flow, what this opposition does, why it is needed, and how it is used. The module is divided into four lessons: characteristics of resistance, resistors, resistor values, and ohmmeters. Each lesson consists of an overview, a list of study resources, lesson narratives, programed instructional materials, and lesson summaries. (Author/BP)

NAVPERS 94558-3a

BASIC ELECTRICITY AND ELECTRONICS

INDIVIDUALIZED LEARNING SYSTEM

MODULE THREE
RESISTANCE

Study Booklet

BUREAU OF NAVAL PERSONNEL

January 1972

O V E R V I E W

MODULE THREE

Resistance

In this module you will learn of the opposition offered to electron current flow. You will learn what this opposition does, why it is needed, and how it is used. You will further learn about the instrument used to measure this opposition and how to use it.

For you to more easily learn the above, this module has been divided into the following four lessons:

Lesson I.	Characteristics of Resistance
Lesson II.	Resistors
Lesson III.	Resistor Values
Lesson IV.	Ohmmeters

Do not be concerned at this time with names or terms unfamiliar to you. Each will become clear as you proceed. However, if you have any questions, do not hesitate to call your instructor. Turn to the following page and begin Lesson I.

BASIC ELECTRICITY AND ELECTRONICS
INDIVIDUALIZED LEARNING SYSTEM

MODULE THREE
LESSON I

Characteristics of Resistance

Study Booklet

OVERVIEW
LESSON I

Characteristics of Resistance

In the lesson you will study and learn about the following:

- conductors
- non-conductors
- how resistance is used

Each of the above topics in this lesson will be discussed in the order listed. As you proceed through this lesson, observe and follow directions carefully.

BEFORE YOU START THIS LESSON, PREVIEW THE LIST OF STUDY RESOURCES ON THE NEXT PAGE.

LIST OF STUDY RESOURCES

LESSON I

Characteristics of Resistance

To learn the material in this lesson, you have the option of choosing, according to your experience and preferences, any or all of the following:

STUDY BOOKLET:

- Lesson Narrative
- Programmed Instruction
- Lesson Summary

ENRICHMENT MATERIAL:

NAVPERS 93400A-1a "Basic Electricity, Direct Current." Fundamentals of Electronics. Bureau of Naval Personnel. Washington, D.C.: U.S. Government Printing Office, 1965.

Remember, you may study all or any of these that you feel are necessary to answer all Progress Check questions correctly. Do not forget that in one sense of the word your instructor is a living resource; perhaps the best. Call him if you have any kind of a problem.

YOU MAY NOW STUDY ANY OR ALL OF THE RESOURCES LISTED ABOVE. YOU MAY TAKE THE PROGRESS CHECK AT ANY TIME.

NARRATIVE
LESSON I

Characteristics of Resistance

Resistance

So far you have learned about two electrical quantities present in any circuit, and have seen or measured their effects in your power supply and the other circuits you built. These factors are, of course, current flow and voltage.

A third factor present in all circuits is resistance. Resistance is the property that opposes current flow. It might be compared to the friction which opposes the movement of a box across a floor. If you push a heavy box across a nice smooth, polished floor, it will move easily for there is little friction. If, however, the same box is pushed across a rough concrete floor, it will be much harder to push.

In a circuit with little resistance, electrons move easily, and a small voltage will cause a high current flow. This same small voltage will be able to push only a small current through a circuit containing a lot of resistance, for the resistance reduces the flow of electrons in the circuit just as a change in the floor surface affects the effort that is required to move the box.

Electrical resistance usually is represented by the letter R. The unit of measure for resistance is the ohm symbolized by the Greek letter omega (Ω).

Conductors

All materials have some resistance, but some materials have much more resistance than others. This is due to differences in their atomic and chemical structure. Copper is a good conductor. It has many free electrons, so current flows through copper easily. Therefore, copper has low resistance. Some other conductors are aluminum, gold, and silver.

Conductors, then, have low resistance and are used to carry electrons through a circuit to do work in the load or loads in that circuit. By using low resistance conductors, little energy is needed to move the current through the conductor, and almost all the electrons' energy is left to do work in the load.

Non-Conductors

Atoms which do not easily let go of their electrons are characteristic of materials which are called non-conductors or insulators.

Non-conductors have high resistance. We use them to protect people or parts of circuits where we do not want an electrical connection. A good example of an insulator is the plastic sleeves on your test leads. These sleeves protect you from contact with dangerous parts of a circuit when you are making measurements. Glass, rubber, vinyl, mica, and dry air are some other common insulators.

The atomic structure of a material determines basically how much resistance the material has, because it determines how easily electrons can be freed for current flow in a given volume of material. The more free electrons per unit area, the lower the resistance of the material.

The cross-sectional area of the material also affects its resistance. The larger the diameter of a wire, the greater the quantity of free electrons available and the lower the resistance.

The final factor which affects the resistance of a material is its length; the longer the wire, the farther the electrons must travel in the resisting medium, and the higher the resistance. A piece of wire 2 inches long will have twice the resistance of a 1-inch piece of the same wire.

How Resistance Is Used

Much of the work done in electric circuits depends on resistance. When current flows through a resistance, the energy removed from the electrons is given off in the form of heat. In electric toasters, irons, blankets and stoves, this heat is used directly. In a lamp (like the one in your power supply), the filament in the lamp is heated until it glows brightly and provides light. In each case, electrons gain energy from the source, and then give off this added energy in the form of heat when they go through the load.

It is often necessary to limit the current flow in a circuit so that parts of the circuit will not be damaged by too much current. Resistance, in the form of a resistor, is used to do this job. A resistor is a circuit component which contains a measured amount of resistance in one neat package. In the next lesson you will learn more about resistors.

AT THIS POINT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

PROGRAMMED INSTRUCTION
LESSON I

Characteristics of Resistance

TEST FRAMES ARE 10, 21, AND 29. AS BEFORE, GO FIRST TO TEST FRAME 10 AND SEE IF YOU CAN ANSWER ALL THE QUESTIONS THERE. FOLLOW THE DIRECTIONS GIVEN AFTER THE TEST FRAME.

---

1. Recall that current flow is the directed movement of electrons. This movement is not unopposed; all materials offer some opposition to the flow of current. This opposition to current flow is called resistance.

   The purpose of the wires (conductors) in your power supply is to transfer electrical energy with as little loss as possible.

   They have a:

   ___ a. high resistance.
   ___ b. low resistance.

- -

(b) low resistance

---

2. Resistance reduces the amount of electron movement.

   This means that resistance:

   ___ a. assists the movement of electrons.
   ___ b. limits the flow of current.
   ___ c. reduces the applied voltage.
   ___ d. adds electrons.

- -

(b) limits the flow of current

---

3. The term used to describe opposition to current is abbreviated R.

   R stands for ___________.

- -

(resistance)

4. Which correctly defines resistance?

___ a. Resistance is the reduction of applied voltage.
___ b. Resistance is the directed drift of electrons.
___ c. Resistance is the opposition to current.
___ d. Resistance is the limiting of the total number of electrons in a material.

(c) Resistance is the opposition to current.

5. The unit of measure for resistance is the <u>ohm</u>, which is represented by the Greek letter <u>omega</u> (Ω).

If a conductor has 5Ω, this means specifically that the conductor:

___ a. will reduce current by (5Ω) amperes.
___ b. is 5 ohms long.
___ c. has 5 units of opposition.
___ d. will have 5 ohms of current.

(c) has 5 units of opposition

6. Match:

___ 1.	E	a. Ω
___ 2.	R	b. a
___ 3.	I	c. v

(1. c; 2. a; 3. b)

7. An ohm is the unit of resistance which will allow 1 amp of current to flow if 1 volt is applied.

One ohm could also be expressed as:

___ a. 2 volts per amp.
___ b. 1 ohm per amp.
___ c. 1 amp per volt.
___ d. 1 volt per ohm.

(c) 1 amp per volt

8. Which correctly defines the ohm?

___ a. the opposition offered to current by a conductor.
___ b. the unit of measure for electron displacement.
___ c. the resistance that will permit 1 amp of current to flow if 1 volt is applied.
___ d. the unit of measure for applied force.

(c) the resistance that will permit 1 amp of current to flow if 1 volt is applied

9. The symbol used to represent the ohm is:

___ a. v
___ b. a
___ c. E
___ d. Ω
___ e. I

(d) Ω

10. Electrical resistance:

___ a. opposes current flow.
___ b. has little or no effect on current.
___ c. assists voltage.
___ d. limits the amount of current.
___ e. is represented by the letter R and measured in ohms.
___ f. is a measure of the amount of current flow in a wire.

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 10

a. opposes current flow

d. limits the amount of current.

e. is represented by the letter R and measured in ohms.

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 21. OTHERWISE, GO BACK TO FRAME 1 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 10 AGAIN.

11. All matter offers resistance to current. One of the factors which affect resistance is the atomic structure of the material used as a conductor. Since different materials (e.g., silver, lead, copper) have different atomic structures, you can infer that:

___ a. some materials have greater resistance than others.
___ b. materials with atomic structures which offer little opposition are good conductors.
___ c. materials with atomic structures that oppose current are good conductors.

(a. some materials have greater resistance than others; and,
b. materials with atomic structures which offer little opposition are good conductors)

12. Recall that current is the directed drift of free electrons. From this you can infer that materials which are good conductors are those which:

___ a. have electrons that are easily dislodged from the atoms.
___ b. only have electrons that are firmly attached to the atom.
___ c. have many free electrons.

(a. have electrons that are easily dislodged from the atoms; and,
c. have many free electrons.)

13. Metals such as copper have many free electrons as well as electrons capable of being freed easily by a small outside force, so current flows through them easily.

A material is a good conductor because:

___ a. it transfers electrical energy readily.
___ b. it prevents the transfer of electricity.
___ c. its atomic structure requires large amounts of outside force to move electrons.
___ d. little voltage is needed to move a large amount of current.

- -

(a. it transfers electrical energy readily; and, d. little voltage is needed to move a large amount of current.)

14. What are the characteristics of a good conductor?

___ a. many free electrons.
___ b. low resistance to current.
___ c. all electrons firmly attached to atoms.
___ d. transfers electrical energy only at high voltages.
___ e. high current-limiting effect.

- -

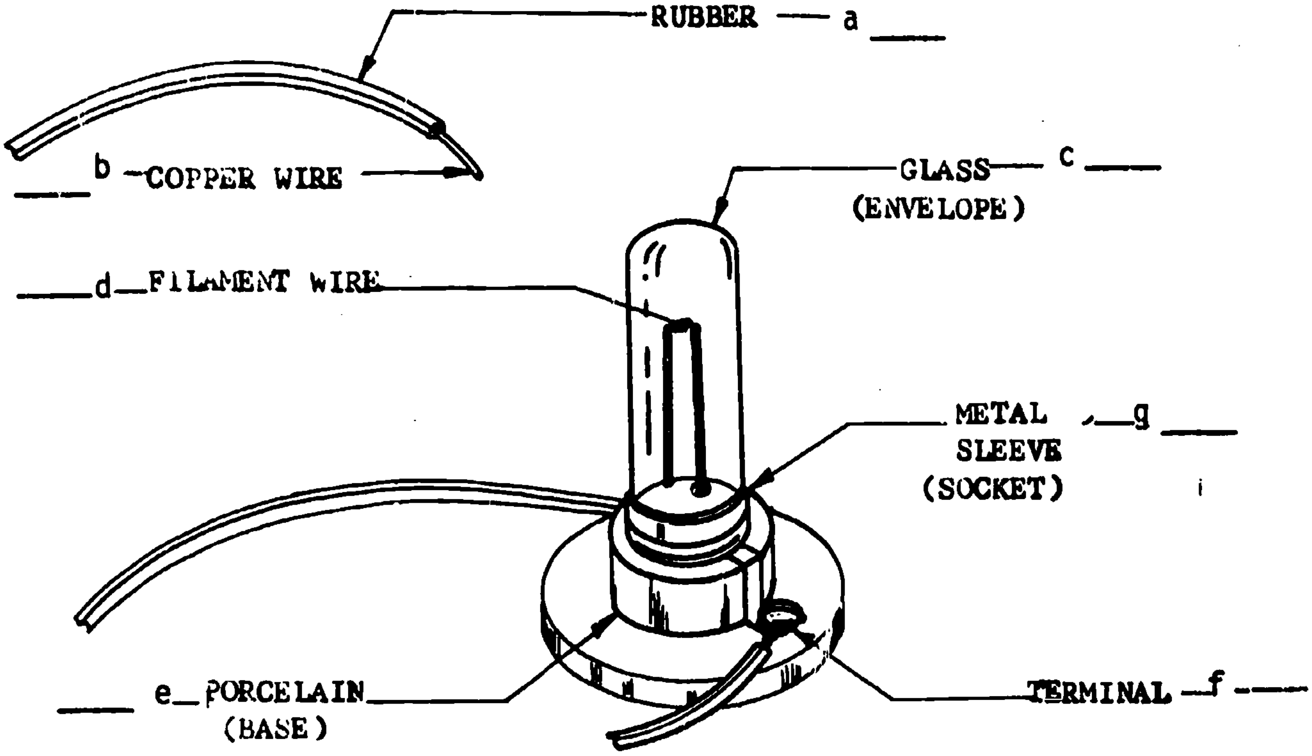
(a. many free electrons; and, b. low resistance to current.)

15. A material in which only a small outside force is required to free an electron would have a low __________ and make a good __________. Materials such as glass, rubber, and most non-metallic materials in which the orbital electrons are firmly held by the parent atoms are called non-conductors or insulators. An insulator __________ transfer electrical energy easily.
would/would not

- -

(resistance, conductor, would not)

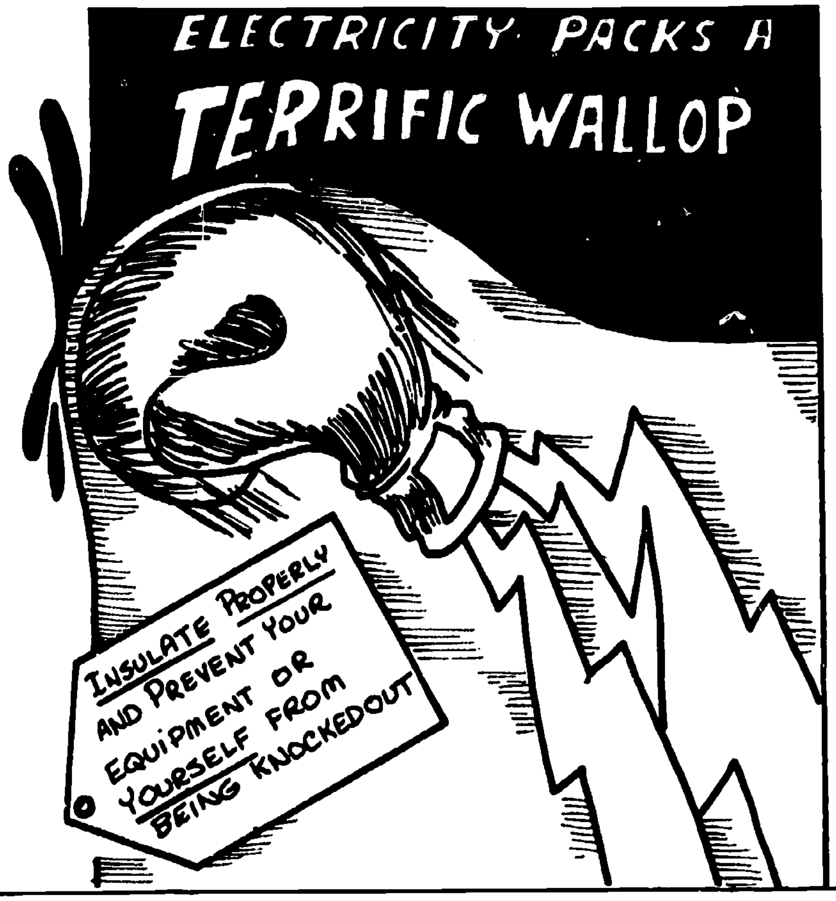
16. Because insulators are poor conductors of electrical energy, they are used to cover conducting materials to prevent an undesired flow of electricity. In the illustration below identify the materials used as insulators by placing a check mark by the appropriate lettered arrows:



- -

(a. rubber; c. glass; e. porcelain)

17. Insulators are used to prevent undesirable current flow. They keep people from coming into contact with the circuit and thus becoming conducting paths themselves; they also protect the circuits from undesired current flow from within, such as a short circuit.



(GO TO NEXT FRAME).

18. Non-conductors or insulators are:

___ a. materials in which electrons do not separate from the atom easily.
___ b. used to prevent an undesired flow of current.
___ c. (both of the above)

(c) both of the above

19. Since non-conductors prevent the transfer of electrical energy, you can say that they have:

___ a. high resistance.
___ b. many free electrons.
___ c. few free electrons.
___ d. low resistance.

(a. high resistance; c. few free electrons)

20. Which of the following correctly describe the characteristics of a conductor?

___ a. has few free electrons
___ b. transfers electrical energy with little loss
___ c. acts as an insulator
___ d. electrons easily separated from atom
___ e. acts as a large opposition to current
___ f. offers small resistance to current
___ g. requires large outside force to move electrons
___ h. has many free electrons

(b. transfers electrical energy with little loss; d. electrons easily separated from atom; f. offers small resistance to current; h. has many free electrons)

21. Match:

____ 1. copper wire		a. conductor
____ 2. many free electrons		
____ 3. glass		b. non-conductor
____ 4. high resistance		
____ 5. electron separation from atom is easy		
____ 6. rubber		
____ 7. few free electrons		

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

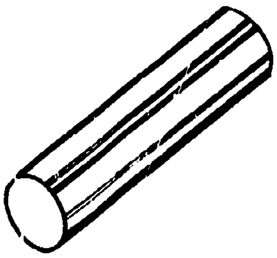
ANSWERS - TEST FRAME 21

1. a
2. a
3. b
4. b
5. a
6. b
7. b

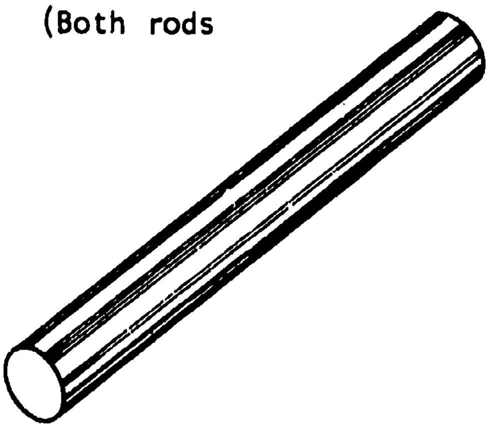
IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 29. OTHERWISE, GO BACK TO FRAME 11 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 21 AGAIN.

22. Recall that one, and perhaps the most important, of the factors affecting the resistance of a conductor is the atomic structure of the material involved. Another factor to consider is the length of the conductor. The longer the conductor the farther the electrons must travel and the higher the resistance.

Which would have the greatest resistance? (Both rods are made of the same material.)



____ a.



____ b.

(b)

23. Resistance in a conductor increases as:

___ a. the length increases.
___ b. the length decreases.

(a) the length increases

24. Conductor length has a direct affect on resistance. Simply stated this means that if length is increased, there will be a corresponding increase in resistance (if all other factors remain the same).

If a copper wire 5 feet long was replaced with a copper wire 10 feet long, resistance would:

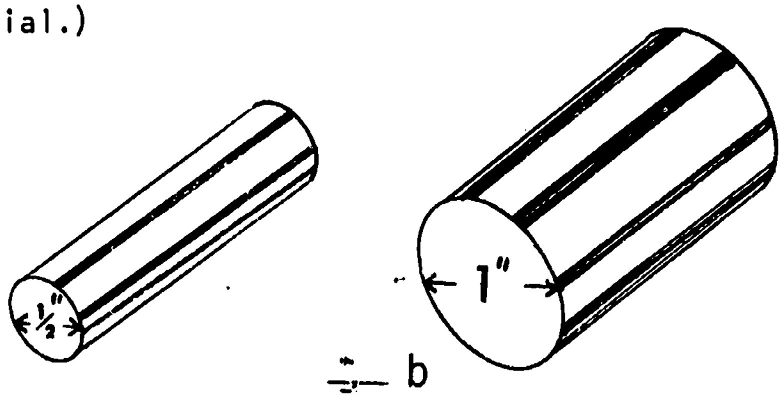
____ a. halve.
____ b. double.
____ c. remain the same.

(b) double

---

25. The final factor to be considered is the cross-sectional area of the conductor. The larger the diameter, the more free electrons available and the lower the resistance.

Which would have the least resistance? (Both rods are made of the same material.)



____ a ____ b

(b)

---

26. Resistance in a conductor increases as:

____ a. diameter increases.
____ b. diameter decreases.

(b) diameter decreases

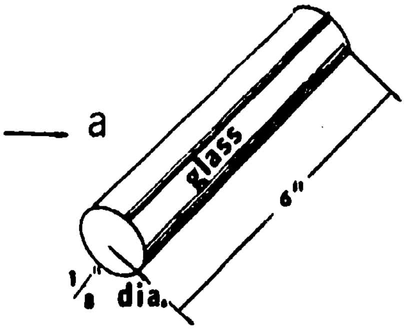
27. If a conductor 4 inches long and 1/4 inches in diameter were stretched to 8 inches with the diameter decreasing to 1/8 inches, its resistance would:

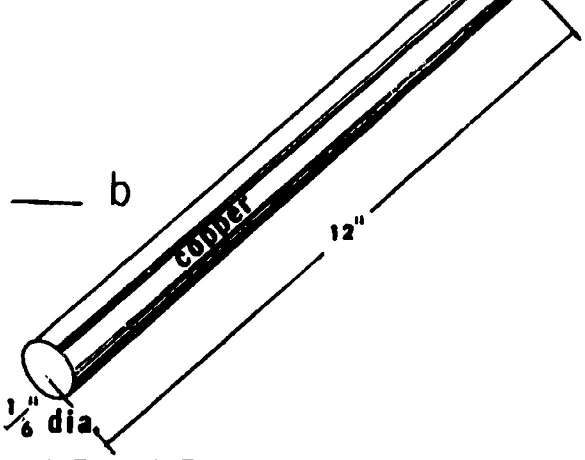
____ a. remain the same.
____ b. decrease.
____ c. increase.

- -

(c) increase

28. The three factors which affect the resistance of a conductor are (1) length, (2) cross-sectional area, and (3) type of material (atomic structure). Of these three, the atomic structure will have the greatest affect on resistance.
Which would have the greatest resistance?





- -

(a)

29. List the factors that affect the resistance of a conductor.

____

____

____

- -

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 29

Atomic structure

Length

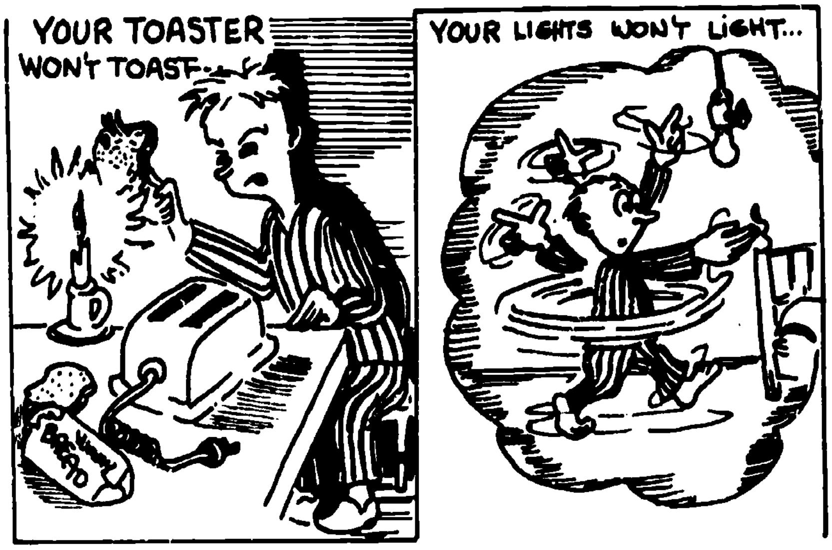
Cross-sectional area (diameter)

- -

IF YOUR ANSWER IS INCORRECT, GO BACK TO FRAME 22 AND TAKE THE PROGRAMMED SEQUENCE.

IF YOUR ANSWER IS CORRECT, GO ON TO THE NEXT FRAME.

30. Resistance in a circuit is needed, otherwise . . .



Much of the work done in electrical circuits is due to resistance. When current flows through a resistance, the energy removed from the electrons is given off in the form of heat. In electric toasters, irons, blankets, and stoves this heat is used directly. In a lamp (like the one in your power supply), the filament in the lamp is heated until it glows brightly, and the heat provides light. In each case, electrons gain energy from the source, then give off this added energy in the form of heat when they go through the load.

Resistance is used to obtain ________________ which may lead to ________________.

- -

(heat; light)

AT THIS POINT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL THE QUESTIONS CORRECTLY, GO ON TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

SUMMARY
LESSON I

Characteristics of Resistance

In addition to current and voltage, all circuits contain resistance, the property that opposes current flow. Resistance in electricity is comparable to friction in mechanics. It is the property that opposes the movement of electrons through a material.

In a circuit with little resistance, a small voltage will cause a large current flow, but the same voltage applied to a circuit with high resistance will result in only a small current flow.

The letter R is the common abbreviation for resistance, as E is often used for voltage and I for current. The unit of measure for resistance is the ohm which is represented by the Greek letter omega (Ω).

Materials which have very low resistance are used as conductors in circuits. Some examples of conductors are gold, silver, aluminum, and copper. The electrons in insulators, or non-conductors, are bound very strongly to the atomic nucleus and cannot easily be broken free for current flow. Some common insulators are glass, rubber, vinyl, mica, and dry air.

The factors which determine the resistance of a component of a circuit are the material it is made of, its cross-sectional area, and its length. The type of material determines how many free electrons will be available in a given volume -- the more free electrons, the lower the resistance.

The cross-sectional area affects resistance because larger diameter wire has more free electrons per inch of length, therefore lower resistance. The longer the wire is, the further electrons must travel in the resistance medium, and the greater the total resisting effect they will encounter in the circuit.

While resistance is seemingly undesirable in a conductor, most of the work done by electricity depends on it. Current flow through the resistance in a toaster, iron, blanket, or stove converts the electrical energy into heat; and in a lamp, wire is heated until it glows brightly. In each case, the energy that electrons receive in the source is converted to heat and other forms of energy when the electrons move through the load.

Resistors are used to limit the current flow through parts of a circuit to safe values. A resistor is a circuit component which has specified amounts of resistance.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK, OR YOU MAY STUDY THE LESSON NARRATIVE OR THE PROGRAMMED INSTRUCTION OR BOTH. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO TO THE NEXT LESSON. IF NOT, STUDY ANOTHER METHOD OF INSTRUCTION UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

BASIC ELECTRICITY AND ELECTRONICS

INDIVIDUALIZED LEARNING SYSTEM

MODULE THREE

LESSON II

Resistors

Study Booklet

OVERVIEW
LESSON II

Resistors

In this lesson you will study and learn about the following:

- -composition resistors
- -wire-wound resistors
- -mechanical differences in resistors

Each of the above topics will be discussed in the order listed. As you proceed through this lesson, observe and follow directions carefully.

BEFORE YOU START THIS LESSON, PREVIEW THE LIST OF STUDY RESOURCES ON THE NEXT PAGE.

LIST OF STUDY RESOURCES

LESSON II

Resistors

To learn the material in this lesson, you have the option of choosing, according to your experience and preferences, any or all of the following:

STUDY BOOKLET:

- Lesson Narrative
- Programmed Instruction
- Lesson Summary

ENRICHMENT MATERIAL:

NAVPERS 93400A-1a "Basic Electricity, Direct Current." Fundamentals of Electronics. Bureau of Naval Personnel. Washington, D.C.: U.S. Government Printing Office, 1965.

You may study whatever learning materials you feel are necessary to answer the questions in the Lesson Progress Check. All your answers must be correct before you can go to Lesson III. Remember your instructor is available at all times for any assistance you may need.

YOU MAY NOW STUDY ANY OR ALL OF THE RESOURCES LISTED ABOVE. YOU MAY TAKE THE PROGRESS CHECK AT ANY TIME.

NARRATIVE
LESSON II

Resistors

Resistors

Resistors are electrical components which are designed and manufactured to have a specific value of resistance. These components are used in electrical circuits to limit or control the amount of current flow.

Resistors are rated in ohms for resistance value and in watts for power-handling capability. The wattage rating refers to the resistor's ability to dissipate the heat caused by current flow, and is the maximum power a resistor can dissipate without damage from overheating. A resistor's wattage rating is determined by its physical size and material used in its construction. Usually, the larger the resistor, the more surface it has exposed to the air and the quicker it can transfer heat to the air.

Resistors are made from several materials and in many shapes. You will study and learn about two of the more common materials, composition (carbon) and resistance wire.

Composition Resistors

The carbon or composition resistor is the most common type of resistor. It is made of a mixture of carbon and clay. Changing the ratio of carbon to clay changes the resistance of the composition. This makes it easy to control the resistance of the mix so that resistors with a wide range of values can be made in standard sizes.

Carbon Resistor

The principal advantages of a carbon resistor are its low cost and the simplicity of its manufacture.

Composition resistors have two major disadvantages:

1. They often change in value with age.
2. They are unable to carry large currents without damage.

All four of the resistors in your power supply are composition resistors.

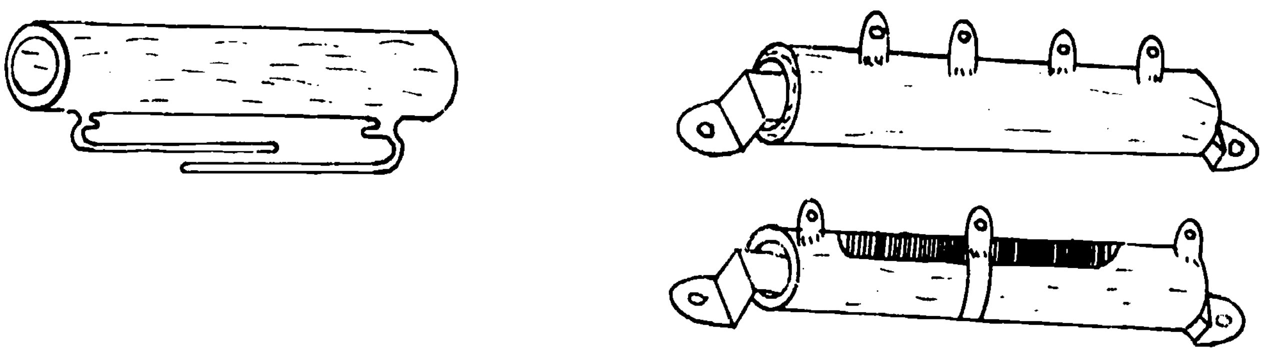
Wire-Wound Resistors

The wire-wound resistor is made from wires which have specified resistance characteristics. The length of wire needed for the resistance desired is wound on a ceramic tube, then coated with an insulating glaze.

Advantages of the wire-wound resistor are that it can carry large currents without damage, it can be made to very accurate resistance values, and it is very stable in value over long periods of time.

Its main disadvantage is the cost of manufacture.

The drawings below show three wire-wound resistors, all slightly different in construction.



Mechanical Differences in Resistors

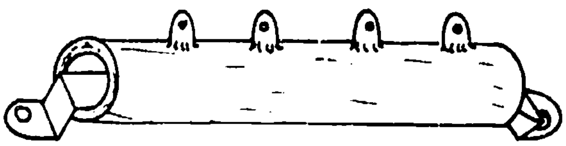
Resistors can be classified according to certain mechanical differences also.

The resistors in your power supply are examples of fixed resistors, that is, they have only one resistance value.

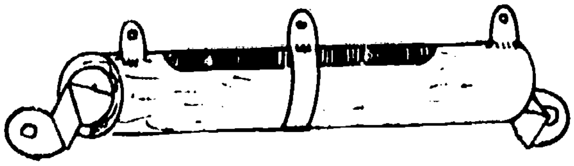
The schematic symbol for a fixed resistor is a zig-zag line: 

Tapped Resistors

Tapped resistors are made with one or more connections available between the two end terminals so that various values of resistance are available from the one resistor. Here is a drawing of a apped resistor, and its schematic symbol:



A variation of this is the sliding-contact resistor. This type of resistor has a tap which can be moved along the resistor. This movement allows the tap to be adjusted to any desired resistance value. Its appearance and schematic diagrams are shown below:

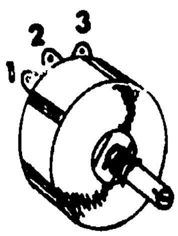


NOTE: The sliding-contact resistor has the schematic symbol of a variable resistor since the amount of resistance used may be varied. Normally, however, the sliding contact is set for the desired resistance, and once set, is seldom changed.

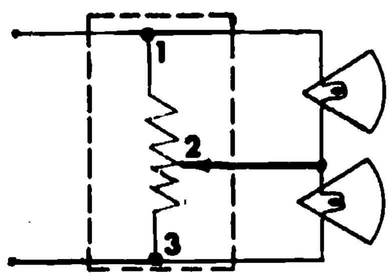
Variable Resistors

A variable resistor is used to change the resistance in a circuit at any time. The volume control on a radio is a variable resistor. Variable resistors are subdivided into potentiometers and rheostats.

A potentiometer has three connections, one at each end with a movable contact between them. It is very similar to the sliding-contact resistor in the way it operates, but it is different in appearance. Here is a drawing of a potentiometer and a schematic diagram of a circuit which uses one.



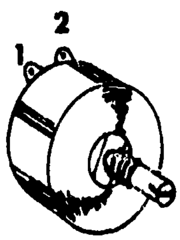
Pictorial



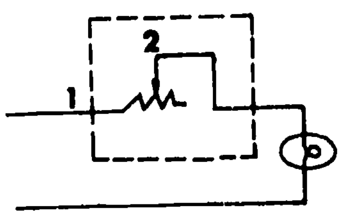
Schematic

The circuit shown controls the way power is divided between front and rear speakers in a car. The volume of sound produced by each speaker is determined by the position of movable contact.

A rheostat uses only two connections, one end connection and a movable contact. A drawing of a rheostat, and a lighting control circuit using a rheostat are shown.



Pictorial



Schematic

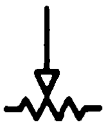
In this circuit, the rheostat controls current flow in the circuit; therefore, it controls the brightness of the light.

Look at Resistor Board 3-1. See your instructor.

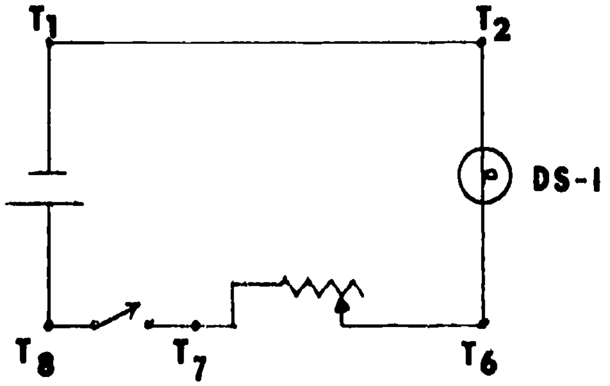
Fill in the blanks and draw the proper schematic symbol for each of the resistors on the display board.

	Type of Construction	Mechanical Type	Schematic
R1	______	______	
R2	______	Fixed	
R3	______	______	
R4	Composition	Fixed	

Compare your answers with the correct answers given below:

	Type of Construction	Mechanical Type	Schematic
R1	Wire-wound	Sliding Contact	 or 
R2	Wire-wound	Fixed	
R3	Wire-wound	Tapped	
R4	Composition	Fixed	

On Practice Board 0-1, connect one dry cell, one lamp, the switch, and the variable 0-10 Ω resistor as shown by this schematic.



Turn the shaft of the variable resistor, and note the changes in the brightness of the light.

AT THIS POINT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

PROGRAMMED INSTRUCTION
LESSON II

Resistors

TEST FRAMES ARE 13, 25, AND 49. GO FIRST TO FRAME 13 AND SEE IF YOU CAN ANSWER ALL THE QUESTIONS THERE. FOLLOW THE DIRECTIONS GIVEN AFTER THE TEST FRAME.

---

1. One thing which must be kept in mind is that resistance is a physical property, affected solely by physical factors. To change a resistance value, something must be done to the conductor, circuit, or device in question.

   If the voltage applied to a circuit were doubled and as a result the current flow also doubled, resistance would:

   ____ a. double.
   ____ b. halve.
   ____ c. quadruple.
   ____ d. not change.

- -

(d) not change

---

2. Resistance is a physical property and can be changed by:

   ___ a. varying the amount of current flow.
   ___ b. increasing or decreasing voltage.
   ___ c. changing components in a circuit.

- -

(c) changing components in a circuit

---

3. It is often necessary to limit current flow so that parts of the circuit will not be damaged by too much current. Resistance, in the form of resistors, can be used to do this job. Resistors are used to:

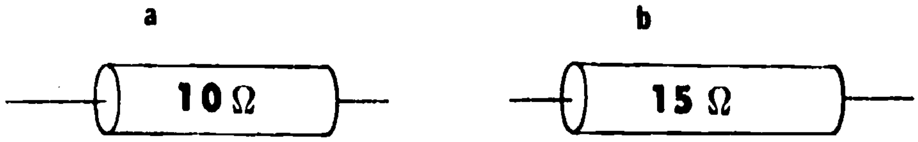
   ___ a. increase current flow.
   ___ b. control current flow.
   ___ c. change the voltage applied to the circuit.

- -

(b) control current flow

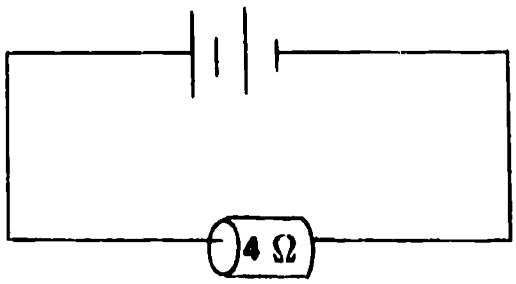
4. A resistor is a circuit component manufactured to have a specific amount of opposition to current flow. This measured amount of resistance is called its ohmic (Ω) value. The greater the ohmic value, the greater the opposition to current flow.

Which resistor would have the greatest resistance to current?



(b)

5. If voltage is held constant, what must be done in order to decrease the amount of current flow in the test circuit below?

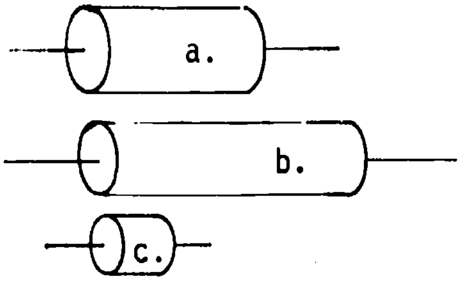


___ a. Replace the 4-ohm resistor with a resistor of higher ohmic value.
___ b. Decrease the length of the wire conductor.
___ c. Add another resistor to the circuit.
___ d. Replace the 4-ohm resistor with a resistor of lower ohmic value.

(a. Replace the 4-ohm resistor with a resistor of higher ohmic value; c. Add another resistor to the circuit.)

6. A resistor may be small in physical size, yet range in resistance from less than 1 ohm to several million ohms.

Which resistor would have the greatest current-limiting effect?



___ a. A
___ b. B
___ c. C
___ d. cannot be determined

- -

(d) cannot be determined

7. Which statement is true?

___ a. It is impossible to determine the ohmic value of a resistor from its physical size.
___ b. The smaller the physical size of a resistor, the larger its ohmic value.
___ c. The ohmic value of a resistor always increases as its size increases.

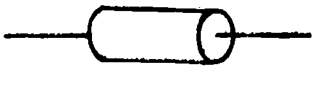
- -

(a) It is impossible to determine the ohmic value of a resistor from its physical size

8. Resistors are also rated in watts as well as ohms. The wattage rating of a resistor refers to its power-handling capability, that is, its ability to dissipate heat. A resistor's wattage rating is determined by its physical size and type of material used. Usually, the bigger the resistor, the more surface it has exposed to the air and the quicker it can transfer heat to the air.

Which resistor would have the highest wattage rating?

___ a.



___ b.

- -

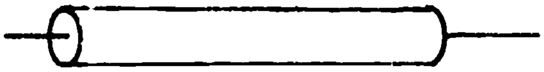
(b)

9. The wattage rating of a resistor is determined by
____________________ and ____________________.

(physical size; type of material used)

10. The power, or wattage, rating of a resistor represents the maximum amount of heat that the resistor can safely dissipate without being damaged or destroyed.

The resistors shown below are of the same type and ohmic value, which resistor can best carry the largest current without damage due to overheating?

___ a. 

___ b. 

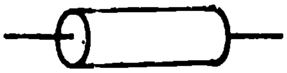
___ c. 

___ d. 

(c)

11. Which resistor must have the largest ohmic value?

___ a. 

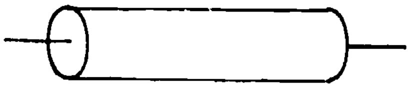
___ b. 

___ c. 

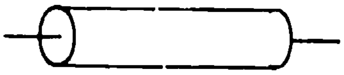
___ d. cannot be determined

(d) cannot be determined

12. If the resistors shown below are of the same type, which resistor would have the highest wattage rating?

___ a. 

___ b.



___ c.

___ d. cannot be determined

(a)

---

13. Check the statements that correctly describe a resistor.

___ a. increases current to load
___ b. constructed to any given value
___ c. ohmic value determined by physical size
___ d. may be used as a load device
___ e. limits current
___ f. cannot be used as a load
___ g. power rating determined by ohmic value
___ h. all resistors of the same size have the same ohmic value
___ i. a manufactured component
___ j. will not affect circuit operation
___ k. will affect circuit operation

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 13

b. constructed to any given value

d. may be used as a load device

e. limits current

i. a manufactured component

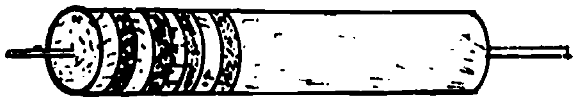
k. will affect circuit operation

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 25. OTHERWISE, GO BACK TO FRAME 1 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 13 AGAIN.

14. Resistors are constructed from several different materials and vary in size and shape. In this frame sequence you will learn about two of the most common types -- composition (carbon) and resistance wire. Read this information carefully. You will be asked about it in the following frames.

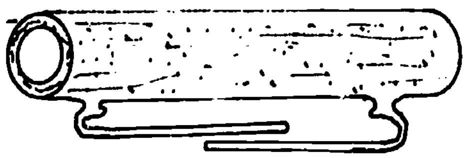
TYPES OF RESISTORS

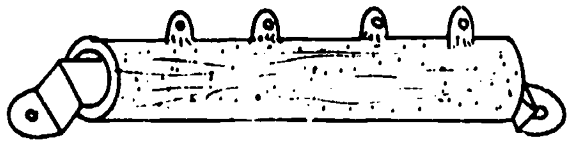
Composition Resistors

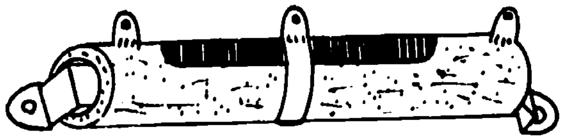


The carbon or composition resistor is the most common type of resistor. It is made of carbon and clay. Changing the ratio of carbon to clay changes the resistance of the composition. This makes it easy to control the resistance of the mix so that resistors with a wide range of values can be made in standard sizes.

Wire-Wound Resistors







The wire-wound resistor is made from wires which have specified resistance characteristics. The length of wire needed for the resistance desired is wound on a ceramic tube, then coated with an insulating glaze.

FIGURE A

REFER TO FIGURE A IN FRAME 14 IN ANSERING FRAMES 15 TO 22.

15. The two basic types of resistors are:

___ a. composition and carbon.
___ b. composition and wire-wound.

(b) composition and wire-wound

16. Another name for a composition resistor is ______________.

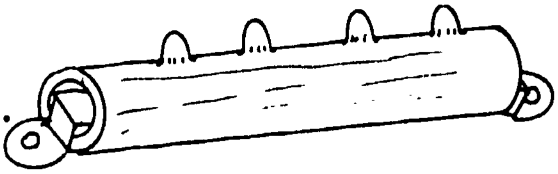
(carbon resistor)

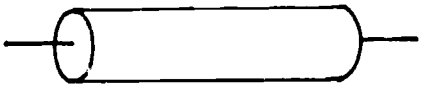
17. Check the way by which a carbon resistor <u>might</u> be identified.

___ a. Several connections are attached along the length of the resistor.
___ b. Mounting brackets are always attached at both ends of the resistor.
___ c. Wire leads, which are parallel to the length of the resistor, extend from the center of both ends.

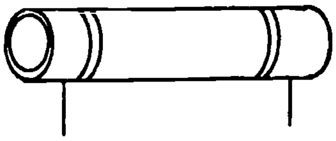
(c) Wire leads, which are parallel to the length of the resistor, extend from the center of both ends.

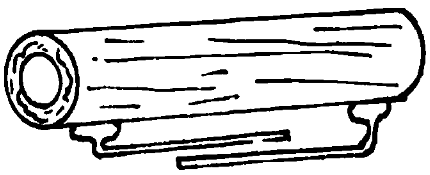
18. Which of the following are carbon resistors?

___ a. 

___ d. 

___ b. 

___ e. 

___ c. 

___ f. 

(b; d; f)

19. Check the statements that are true of carbon resistors.

___ a. The ratio of the carbon-clay mix determines the ohmic value of the resistors produced.

___ b. Varying the ratio of carbon to zinc changes the resistor's wattage rating.

___ c. The resistance value of carbon resistors depends on the length of the wire leads which extend from the ends of the resistor.

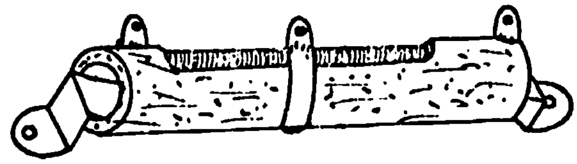
___ d. Standard-size resistors with a wide range of resistance values can be manufactured by varying the ratio of carbon to clay.

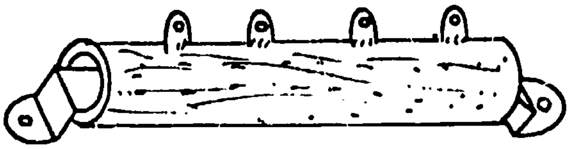
- -

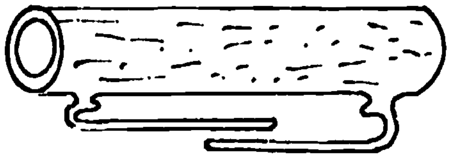
(a. The resistance of the carbon-clay mix determines the ohmic value of the resistors produced; d. Standard-size resistors with a wide range of resistance values can be manufactured by varying the ratio of carbon to clay.)

20. Which of the following are wire-wound resistors?

___ a. 

___ d. 

___ b. 

___ e. 

___ c. 

___ f. 

- -

(b; d; e)

21. Wire-wound resistors are:

___ a. constructed by winding thread around a carbon core.
___ b. constructed of various lengths of resistance wire.
___ c. always made of the same kind and amount of wire and have the same resistance value.
___ d. made of a mixture or composition of wire, carbon, and insulating material.
___ e. the most common type of resistors.

- -

(b) constructed of various lengths of resistance wire

22. Resistors which are made of metal conductors wrapped around a tube of insulation material are known as:

___ a. composition resistors.
___ b. wire-wound resistors.

- -

(b) wire-wound resistors

23. The principal advantages and disadvantages of carbon resistors are listed below. Read them and then answer the question that follows.

Advantages of Carbon Resistors	Disadvantages of Carbon Resistors
1. inexpensive and easy to manufacture	1. ohmic values tend to change with age
	2. low power-handling capabilities
	3. ohmic values not highly accurate, but tolerances usually within acceptable limits for most circuit applications

When would carbon resistors probably be used?

___ a. when precise resistance values are required
___ b. When low cost is a primary consideration and reasonable variations of resistance are acceptable
___ c. when precise long-term operation is required
___ d. when extremely large amounts of heat must be dissipated

- -

(b) when low cost is a primary consideration and reasonable variations of resistance are acceptable

24. The principal advantages and disadvantages of wire-wound resistors are listed below. Read them and then answer the questions that follows. (Note that the advantages of wire-wound resistors are the disadvantages of carbon resistors.)

Advantages of Wire-Wound Resistors	Disadvantages of Wire-Wound Resistors
1. resistance values highly accurate and very stable over long periods of time	1. expensive to manufacture
2. high power-handling capabilities	

When would wire-wound resistors probably be used?

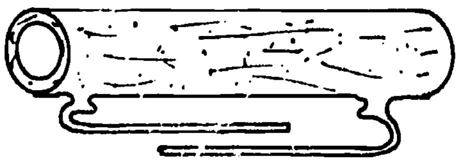
___ a. when high current-handling capabilities are required
___ b. when highly accurate resistance values are required
___ c. when only short-term operation of a circuit is required
___ d. when circuit operation must remain stable for long periods of time
___ e. when low cost requirements are a primary consideration

(a. when high current-handling capabilities are required; b. when highly accurate resistance values are required; d. when circuit must remain stable for long periods of time)

25. Match.

___ 1. inexpensive
___ 2. very accurate values
___ 3. easy to manufacture
___ 4. low power-handling capability
___ 5. expensive
___ 6. high power-handling capability

a. 

b. 

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 25

1. a
2. b
3. a
4. a
5. b
6. b

- -

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 49. OTHERWISE, GO BACK TO FRAME 14 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 25 AGAIN.

26. In addition to classifying resistors in terms of the ________ from which they are constructed (composition and resistance wire), resistors can be classified also according to the number of resistance values they are capable of supplying. The three classifications of resistors are: fixed resistors, tapped resistors, and variable resistors.

- -

(materials)

27. The carbon resistors in your power supply are made for one value of resistance and cannot be changed. Resistors with only one set ohmic value are classified as:

___ a. fixed resistors.
___ b. variable resistors.
___ c. tapped resistors.

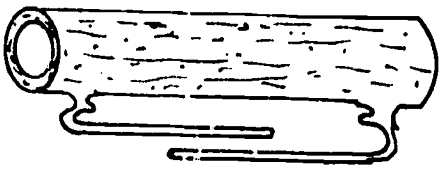
- -

(a) fixed resistors

28. Below are two examples of fixed resistors.

Carbon Resistor

Wire-Wound Resistor



These resistors have:

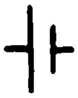
___ a. several resistance values.
___ b. only one resistance value.

- -

(b) only one resistance value

29. The schematic symbol for a fixed resistor is a jagged, zig-zag line.

Which is the schematic symbol for a fixed resistor?

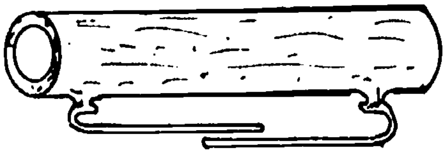
___ a. 
___ b. 
___ c. 
___ d. 

- -

(c)

30. Draw the schematic symbol below the resistors illustrated.

a.



____

____

b.

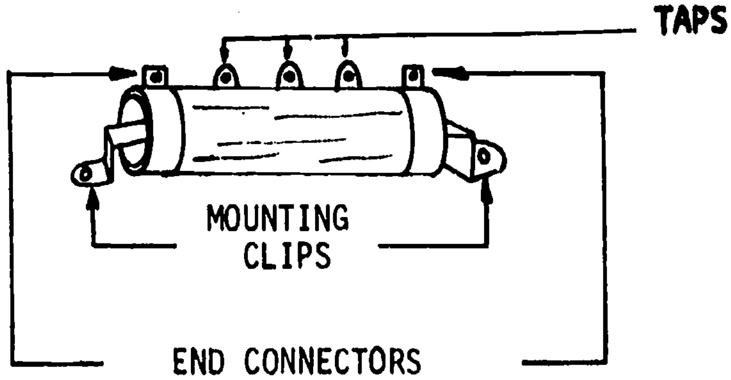
____

____

- -

(a.  b. )

31. A tapped resistor is made with one or more connections (taps) securely fastened between two end terminals.



The resistor illustrated has how many taps? ____________

(three)

---

32. Each two connections on a tapped resistor provides a specific value of resistance.

A tapped resistor can furnish:

___ a. only one set value of resistance.
___ b. more than one value of resistance.

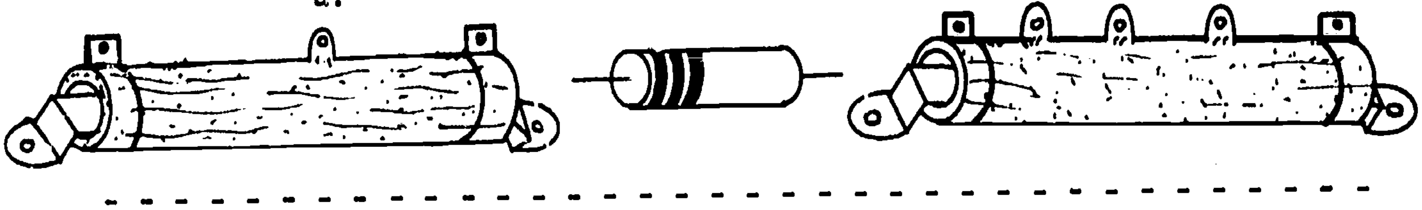
(b) more than one value of resistance

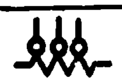
---

33. The schematic symbol for a tapped resistor is  Each perpendicular line represents a tap.

Draw the appropriate schematic symbol below each resistor illustrated.

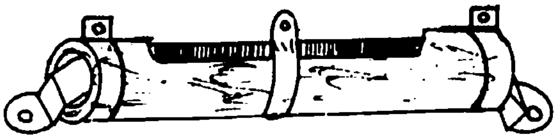
a. b. c.

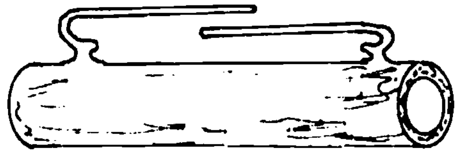


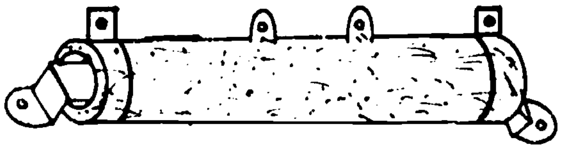
(a.  b.  c. )

34. A variable resistor is used to change the resistance in a circuit whenever necessary. One type of variable resistor is the <u>sliding-contact resistor</u>. The sliding-contact resistor is made with an adjustable connection or collar that can be moved along the resistor to obtain any desired resistance value within the range of the resistor.

Which of the following is a sliding-contact resistor?

___ a. 

___ b. 

___ c. 

- -

(a)

(NOTE: The sliding-contact resistor has the schematic symbol of a variable resistor, and the amount of resistance used may be varied. Normally, however, the sliding contact is set for the desired amount of resistance and once set is seldom changed.)

35. One schematic symbol for variable resistors is a jagged, zig-zag line with a sloping arrow cutting across it.

Which would be the schematic symbol for a sliding-contact resistor?

___ a. 

___ b. 

___ c. 

___ d. 

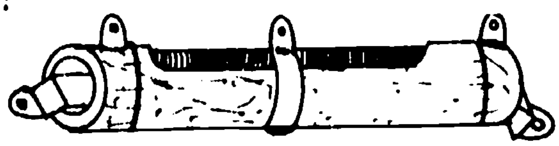
- -

(c)

36. Variable resistors can also be represented schematically by

The arrow indicates the moveable contact. 

Check the schematic symbols which would be used with the resistor below:



___ a.    ___ c. 

___ b.    ___ d. 

- -

(a; b)

37. Match the resistors to the appropriate characteristics.

___ 1. has only one resistance value — a. tapped resistor

___ 2. represented schematically by  — b. fixed resistor

___ 3. represented schematically by  or  — c. variable resistor

___ 4. represented schematically by 

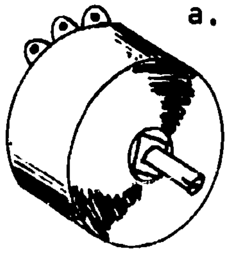
___ 5. has more than one specific value of resistance available depending on how it is connected

- -

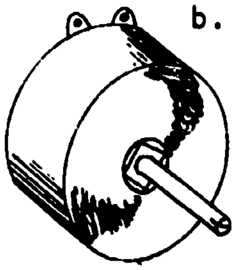
(1. b; 2. a; 3. c; 4. b; 5. a)

38. The two remaining types of variable resistors are the rheostat and the potentiometer. The rheostat has two circuit connections and the potentiometer has three connections. Identify the variable resistors below as either a rheostat or a potentiometer by writing the name below the illustration.

a.



b.

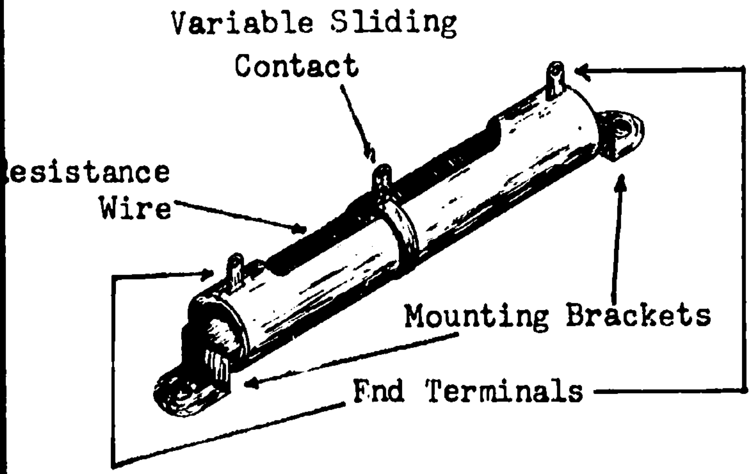


______________ ______________

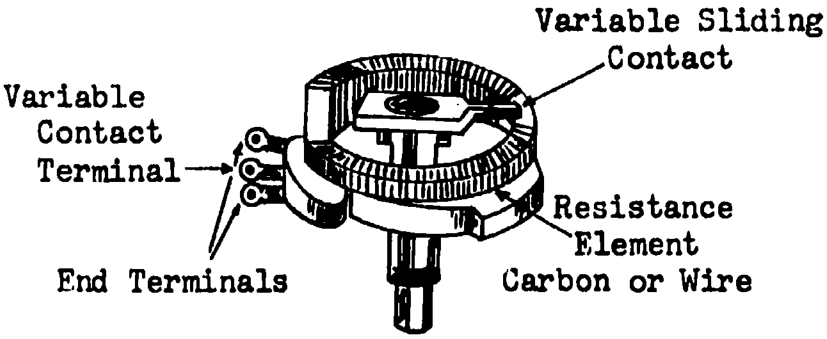
(a. potentiometer; b. rheostat)

(NOTE: There are as many connections in a rheostat and a potentiometer as there are t's in the words rheostat and potentiometer.)

39. Although different in appearance, a potentiometer and sliding-contact resistor operate in a similar way. The potentiometer is used in a circuit where frequent changes in resistance are necessary while the sliding-contact is used in cases where changes are seldom required. Both have three connections, one at each end with a sliding contact between them, which can be adjusted to any ____________ desired.



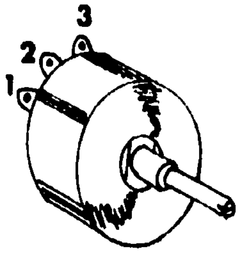
SLIDING CONTACT RESISTOR



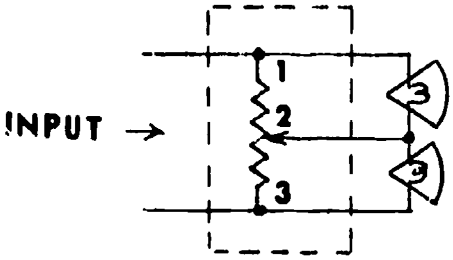
POTENTIOMETER

(resistance)

40. Here is a drawing of a potentiometer and a schematic of a circuit which uses one.



Pictorial



Schematic

The circuit shows how a potentiometer regulates the volume of sound coming from the front and rear speakers of a car radio. The arrow represents the adjustable or variable contact.

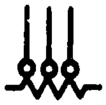
Which statement is true?

___ a. The volume of sound coming from both speakers depends on the position of the variable sliding contact.
___ b. A potentiometer has one end terminal and two variable sliding contacts.

- -

(a) The volume of sound coming from both speakers depends on the position of the variable sliding contact

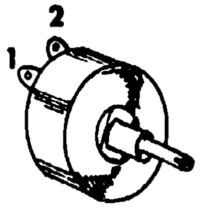
41. Recall that a variable resistor is represented schematically by  , in which the arrow represents the adjustable control or sliding contact. Since a potentiometer must be connected at three points in a circuit, it's schematic symbol would be:

___ a. 
___ b. 
___ c. 
___ d. 

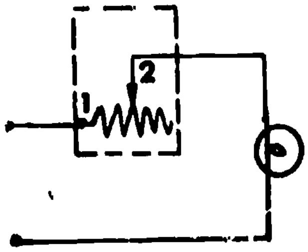
- -

(d)

42. Here is a drawing and a schematic of a rheostat. A rheostat differs from a potentiometer in that it uses only one end terminal and a sliding contact.



Pictorial



Schematic

Which statements are true?

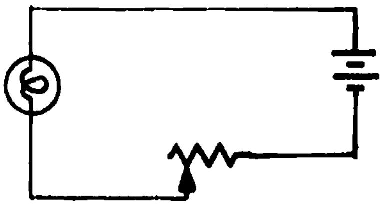
___ a. A rheostat has two connections.
___ b. The schematic symbol for a rheostat is 

___ c. The schematic symbol for a rheostat is 

___ d. A rheostat has three connections - two end terminals and a moveable contact.

(a. A rheostat has two connections; c. The schematic symbol for a rheostat is )

43. Here is a schematic of a lighting control circuit in which a rheostat is used to control current flow in the circuit.



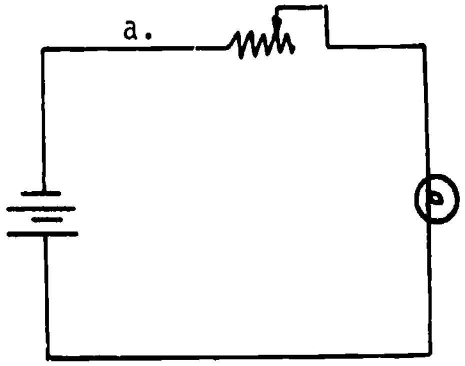
If the rheostat is adjusted so that the amount of resistance decreases, what happens to the light?

___ a. The light dims.
___ b. The light burns more brightly.
___ c. There would be no change in the intensity of the light.

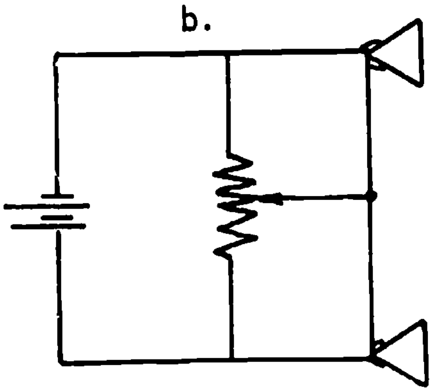
(b) The light burns more brightly

44. Below each schematic, write the name of the variable resistor used in the circuit.

a.



b.

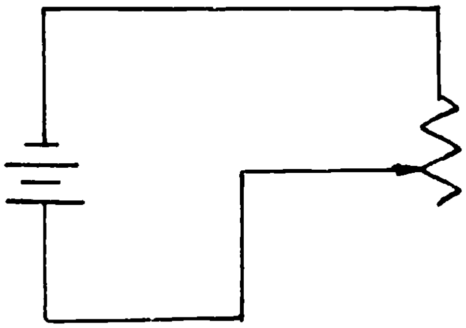


__________ __________

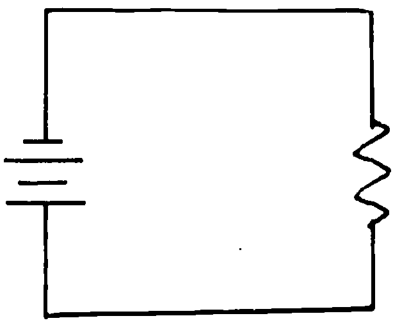
(a. rheostat; b. potentiometer)

45. In which circuit can current flow be changed without replacing either the resistor or the battery?

____ a.



____ b.



(a)

46. Match the illustrations to the appropriate characteristics.

___ 1. fixed value

___ 2. fixed wire-wound

___ 3. variable resistance

___ 4. two fixed - one variable contact

___ 5. low power-handling capability

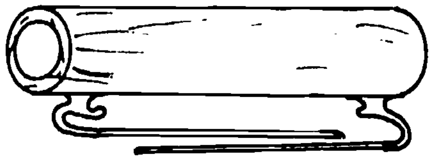
___ 6. fixed carbon-clay composition

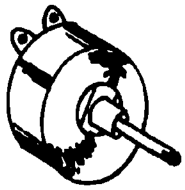
___ 7. tends to change value with age

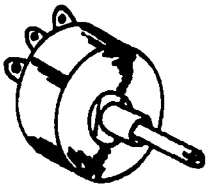
___ 8. potentiometer

___ 9. rheostat

a. 

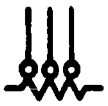
b. 

c. 

d. 

(1. a & b; 2. b; 3. c & d; 4. d; 5. a; 6. a; 7. a; 8. d; 9. c)

47. Match.

___ 1. 

___ 2. 

___ 3. 

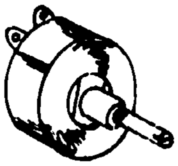
a. fixed

b. tapped

c. variable

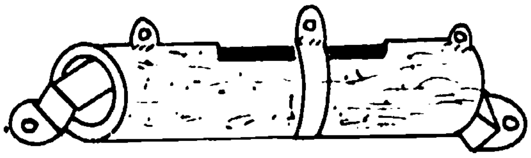
(1. b; 2. c; 3. a)

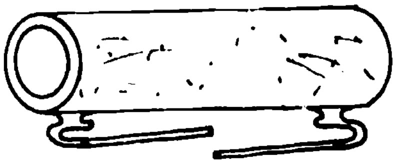
48. Match.

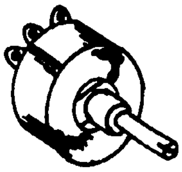
___ 1. 

___ 2. 

___ 3. 

___ 4. 

___ 5. 

___ 6. 

a. wire-wound (fixed)

b. rheostat

c. sliding-contact

d. tapped

e. carbon (fixed)

f. potentiometer

(1. b; 2. d; 3. e; 4. c; 5. a; 6. f)

49. List the kind of resistor and draw the proper schematic symbol for each of the resistors on Practice Board 3-1. See your instructor.

	Type of Construction	Mechanical Type	Schematic
R1			
R2			
R3			
R4			

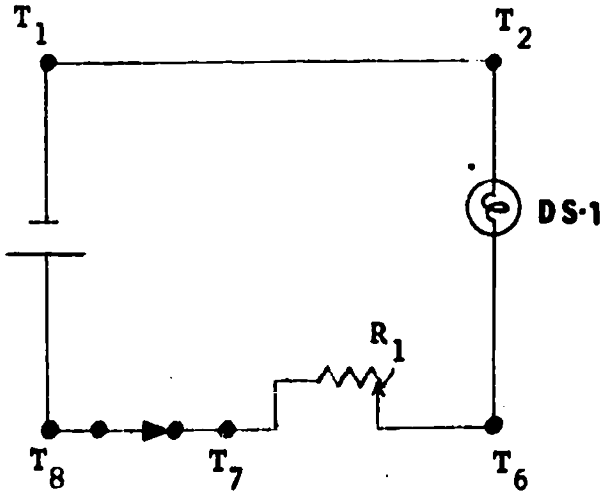
(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 49

	Type of Construction	Mechanical Type	Schematic
R1	Wire-Wound	Sliding-Contact	
R2	Wire-Wound	Fixed	
R3	Wire-Wound	Tapped	
R4	Composition	Fixed	

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO FRAME 50. OTHERWISE, GO BACK TO FRAME 26 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING FRAME 49 AGAIN.

50. On Practice Board 0-1, connect one dry cell, one lamp, the switch, and the 0-10 ohm variable resistor as shown by this schematic:



Turn the shaft of the variable resistor and note the changes in the brightness of the light.

AT THIS POINT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL THE QUESTIONS CORRECTLY, GO ON TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

SUMMARY
LESSON II

Resistors

Resistors are components which are manufactured to have a given amount of resistance and are placed in electrical circuits to limit and control the amount of current flow. Resistors are rated in ohms for resistance value and in watts for power-handling capability.

Although resistors are made of many materials and in many shapes, we will cover only two of the most common materials and the shapes most often used for them.

The first resistor material you will study is called composition or carbon. The composition resistor is made of a mixture of carbon and clay which is inexpensive to manufacture and allows easy control of resistance values. It has two major disadvantages; it may change in value with age, and it is not able to dissipate a large amount of heat without damage. The resistors in your power supply are all composition resistors.

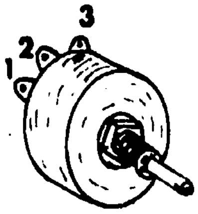
Wire-wound resistors are made from wire which has specific resistance values. The length of wire needed for a particular resistance is wound on a ceramic tube, then covered with an insulating glaze. These resistors are very stable over long periods of time, can be made to very accurate values, and can be built to dissipate a large amount of heat. Their main disadvantage is the cost of making them.

Resistors can be classified according to certain mechanical differences as well as the material from which they are made. The most often used class is the fixed resistor. These resistors are made so that they have only one value of resistance. The schematic symbol for a fixed resistor is a zig-zag line like this:  .

Tapped resistors are made with one or more connections between the two end terminals so that one resistor may provide more than one resistance value. Its schematic symbol is shown here:  .

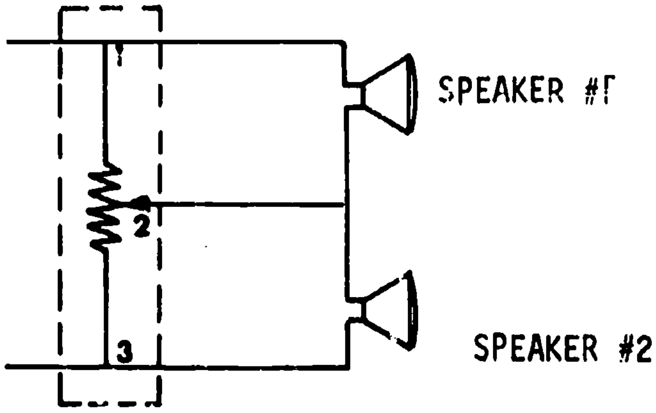
A variation of the tapped resistor is the sliding-contact Resistor, which has a movable tap that can be adjusted to any value in the resistor's range. It is schematically represented by  or  .

A potentiometer is a variable resistor with three connections, the center one movable. The drawings on the next page show a potentiometer and a circuit which uses a potentiometer to control power distribution between two speakers.



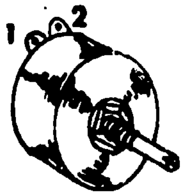
Pictorial

INPUT

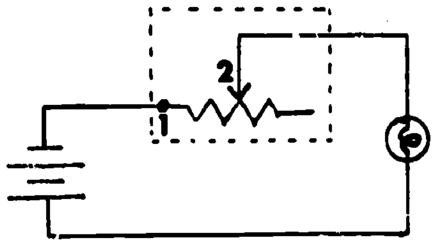


Schematic

A rheostat controls current flow in a circuit and uses only two connections. Here a rheostat is shown wired to vary the brightness of a lamp.



Pictorial



Schematic

If you feel you need more information about resistors, continue studying this lesson; if not, perform the experiments at the end of the narrative.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK, OR YOU MAY STUDY THE LESSON NARRATIVE OR THE PROGRAMMED INSTRUCTION OR BOTH. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO ON TO THE NEXT LESSON. IF NOT, STUDY ANOTHER METHOD OF INSTRUCTION UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

BASIC ELECTRICITY AND ELECTRONICS

INDIVIDUALIZED LEARNING SYSTEM

MODULE THREE

LESSON III

Resistor Identification

Study Booklet

OVERVIEW

LESSON III

Resistor Color Code

In this lesson you will study and learn about the following:

-resistor marking
-the color code
-wattage ratings
-part numbering system

Each of the above topics will be discussed in the order listed. As you proceed through this lesson, observe and follow directions carefully.

BEFORE YOU START THIS LESSON, PREVIEW THE LIST OF STUDY RESOURCES ON THE NEXT PAGE.

LIST OF STUDY RESOURCES
LESSON III
Resistor Identification

To learn the material in this lesson, you have the option of choosing, according to your experience and preferences, any or all of the following:

STUDY BOOKLET:

Lesson Narrative

Programmed Instruction

Lesson Summary

ENRICHMENT MATERIAL:

NAVPERS 93400A-1a "Basic Electricity, Direct Current." Fundamentals of Electronics. Bureau of Naval Personnel. Washington, D.C.: U.S. Government Printing Office, 1965.

E.I.M.B.

AUDIO-VISUAL

Sound/Slide Presentation - "Resistor Color Code"

You may study whatever learning materials you feel are necessary to answer the questions in the Lesson Progress Check. All your answers must be correct before you can go to Lesson IV. Remember, your instructor is available at all times for any assistance you may need.

YOU MAY NOW STUDY ANY OR ALL OF THE RESOURCES LISTED ABOVE. YOU MAY TAKE THE PROGRESS CHECK AT ANY TIME.

NARRATIVE
LESSON III

Resistor Identification

Introduction

You have learned that current (I) is measured in amperes (a), voltage (E) in volts (v), and now you are dealing with a quantity called resistance (R). Resistance also is measurable, and its unit of measurement is the ohm, symbolized by the Greek letter Omega (Ω). Omega is used because it sounds like ohm. Metric prefixes are used with ohm also; kilohm and megohm are the most common.

One ohm is defined as the amount of resistance which permits 1 ampere of current to flow when an EMF of 1 volt is applied across it.

Pause for a moment now to review all the alphabetic symbols we have so far used:

I stands for current measured in amperes (a).
E stands for voltage measured in volts (v).
R stands for resistance measured in ohms (Ω).

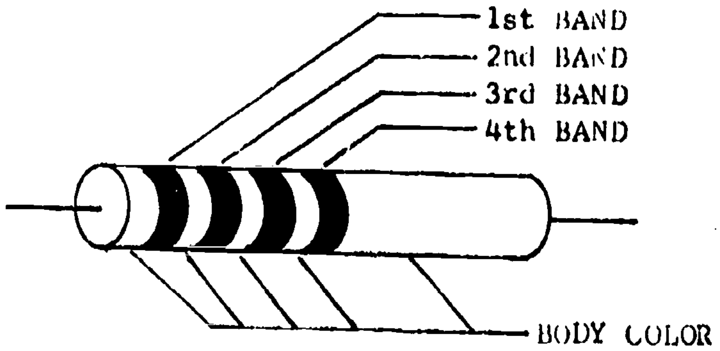
Write the following sentences as equations using the above abbreviations.

1. The EMF is 60 volts.
2. Current flow equals 3 milliamperes.
3. The circuit has a resistance of 10 megohms.

Answer: 1. E = 60 v; 2. I = 3 ma; 3. R = 10 MΩ

Resistor Marking

Resistors like the ones in your power supply are commonly marked with bands of color to indicate their resistance values.



Always start at the end of the resistor which has the least body color showing. The color of the first band tells us the first number in the resistance value and the second band tells us the second digit. The third band indicates the number of zeros to be used behind the second digit.

The fourth band also has a special significance. It tells you how accurately the resistor was manufactured. This band shows the resistor's tolerance as a percentage of the resistance value.

To summarize, the color bands on the resistor indicate values as follows:

First band - first significant digit
Second band - second significant digit
Third band - decimal multiplier (number of zeros to add)
Fourth band - tolerance

The Color Code

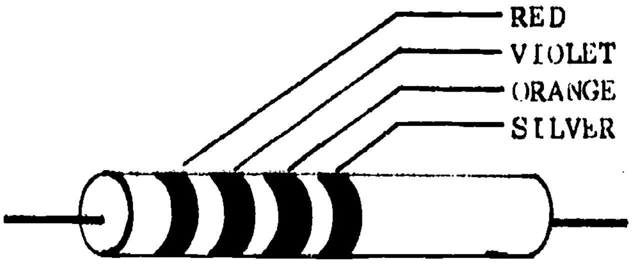
Now that you know what the bands mean, study the color code used to indicate resistance values. The standard color code used for these bands is shown below, along with a nonsense sentence to help you remember the values.

COLOR	NUMBER	SENTENCE
Black	0	Bad
Brown	1	Boys
Red	2	Race
Orange	3	Our
Yellow	4	Young
Green	5	Girls
Blue	6	Behind
Violet	7	Victory
Gray	8	Garden
White	9	Walls

		TOLERANCE	
Gold	*.1	± 5%	Get
Silver	*.01	± 10%	Started
No color		± 20%	Now

*When this color is used as a multiplier (third band).

To help tie all this together, we will go through the procedure for reading the value of one resistor. Then you can practice reading some others. The resistor we are going to use has color bands of red, violet, orange, and silver.



The red band says that the first number of the resistance value is 2. The second number is 7, as shown by the violet band. We now know that the value of the resistor is 27 times some power of ten. The third (orange) band tells us that the multiplier is 10 to the third power or 1000. The value of the resistor is about 27,000 ohms. NOTE: When the color of the third band is gold or silver, the ohmic value of a resistor should be less than 10 ohms.

The silver band indicates that this resistor has a tolerance of ± 10 percent, that is, the value is not more than plus 10 percent nor less than minus 10 percent of the indicated number. For this resistor, 10 percent of 27,000 is 2700, so the value of the resistor should not be more than 29,700 (27,000 + 2,700 = 29,700) nor less than 24,300 (27,000 - 2,700 = 24,300).

If there is no fourth band on a resistor, it has a tolerance of ± 20 percent. This is what is meant by <u>no color</u> in the color code chart.

Draw Resistor Practice Board 3-2 from the resource center and fill in the following table for the resistors on the board.

Resistor #	Value	Tolerance
R1		
R2		
R3		
R4		
R5		

Answer: TURN RESISTOR PRACTICE BOARD OVER AND CHECK YOUR ANSWERS.

Another popular method of resistor identification is the <u>Part Numbering System</u> which uses a series of letters and numbers to completely describe a resistor.

RB31	P	102	G
Style-(wire wound composition, variable, tapped etc.)	Characteristics (effects of temperature)	Resistance Value	Tolerance

The number we are primarily concerned with is that indicating the resistance value. The value of resistance may be indicated by three, four, or five digits. In each case, the last digit dictates the number of zeros to be added to the significant figures represented by the first two, three, or four digits. For the example shown, the first two numbers (10) represent the significant figures and the last digit indicates the number of zeros to be added, so 102 translates to 1000 ohms.

Indication of the value of a precision resistor may require the use of a decimal. When this occurs, an R is placed in the resistance value group such as 132R6. This indicates a resistance of 132.6 ohms.

AT THIS POINT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

PROGRAMMED INSTRUCTION
LESSON III

Resistor Identification

TEST FRAMES ARE 6, 33, AND 43. AS BEFORE, GO FIRST TO TEST FRAME 6 AND SEE IF YOU CAN ANSWER ALL THE QUESTIONS THERE. FOLLOW THE DIRECTIONS GIVEN AFTER EACH TEST FRAME.

---

1. You have learned that current is measured in amperes, voltage in volts, and resistance in ohms.

   Which correctly matches the letter abbreviations to their appropriate unit of measure?

   ___ a. R - volts
   E - amps
   I - ohms

   ___ c. E - volts
   I - amps
   R - ohms

   ___ b. I - amps
   R - volts
   E - ohms

- -

(c) E - volts; I - amps; R - ohms

---

2. Which correctly matches the unit of measure to its appropriate symbol?

   ___ a. volts - v
   amps - a
   ohms - Ω

   ___ c. ohms - a
   volts - Ω
   amps - v

   ___ b. volts - Ω
   amps - a
   ohms - v

- -

(a) volts - v; amps - a; ohms - Ω

---

3. Using the proper letter abbreviations and symbols, write the following sentences as mathematical equations.

   a. The EMF is 60 volts. ___________
   b. Current flow equals 3 milliamperes. _______________
   c. The circuit has a resistance of 10 megohms. _____________

- -

(a. E = 60 v; b. I = 3 ma; c. R = 10 MΩ)

4. In this lesson we are concerned with resistance.
The unit of measure for resistance is the ___________.

(ohm)

5. An ohm is the amount of resistance which permits 1 ampere of current to flow when an EMF of 1 volt is applied across it. This means that if a resistor with a resistance value of 5 ohms is placed in a circuit and an EMF of 1 volt is applied:

___ a. 5 amps of current will flow.
___ b. 0.5 amps of current will flow.
___ c. 1/5 or 0.2 amps of current will flow.
___ d. 1 amp of current will flow

(c) 1/5 or 0.2 amps of current will flow

6. Which correctly defines the ohm?

___ a. all opposition to current and voltage.
___ b. the unit of measure for electron displacement.
___ c. the unit of measure for applied force.
___ d. the resistance that permits 1 amp to flow if 1 volt is applied.

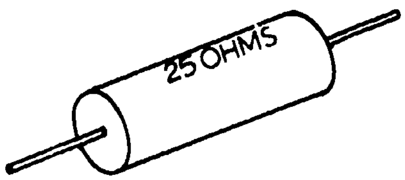
(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWER GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 6

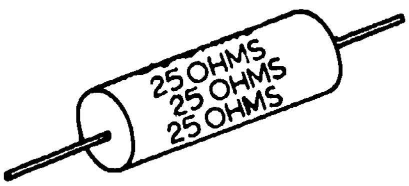
d. the resistance that permits 1 amp to flow if 1 volt is applied

IF YOUR ANSWER IS CORRECT, YOU MAY GO ON TO TEST FRAME 33. OTHERWISE, GO BACK TO FRAME 1 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 6 AGAIN.

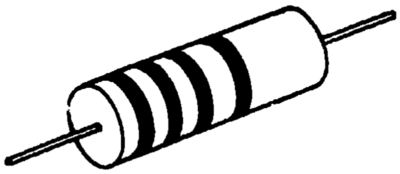
7. Resistors possess a measured amount of _______ and are put into a circuit to limit or control current flow. Because it is not always practical to indicate a carbon resistor's ohmic value by using numbers, colored bands around the resistor are used instead.



This method would probably have the numbers hidden.



This method would be costly.

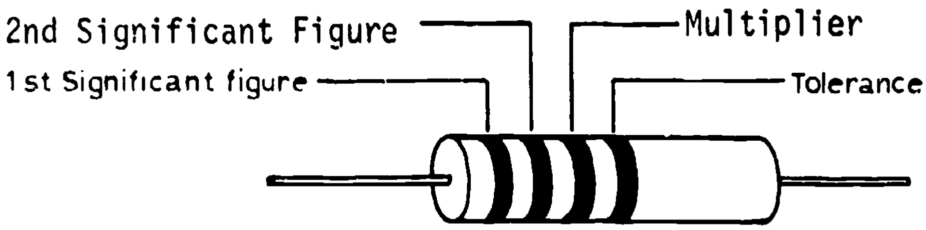


The color code method is the most practical.

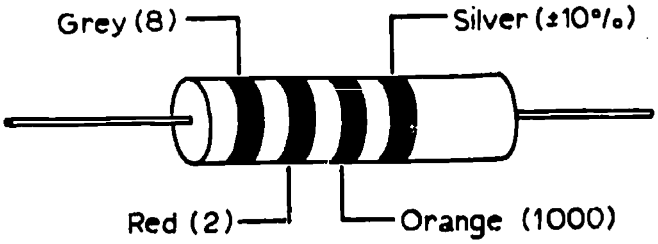
Knowledge of the resistor color coding system will assist you in locating and identifying a resistor in a piece of equipment.

(resistance)

8. Each colored band on a resistor has a meaning as shown in the illustration below.



The actual numerical value assigned to the band will be determined by its color as shown below.



Ohmic value
82,000Ω ± 10%

- -

(go to the next frame)

9. In determining a resistor's ohmic value, always start from the colored band closest to an end of the resistor.

At what end should you start in reading the ohmic value of the following resistors?

___ 1.

___ 2.

___ 3.

___ 4.

- -

(1. a; 2. b; 3. b; 4. a)

10. The first band represents the first number (1st significant figure) in the resistance value.

If a resistor's ohmic value was 820 ohms, which number would be represented by the first band?

___ a. 8
___ b. 2
___ c. 0

(a) 8

11. The second band represents the second significant figure in the resistance value.

If a resistor's ohmic value was 4300 ohms, which number would be represented by the second band? ___

---

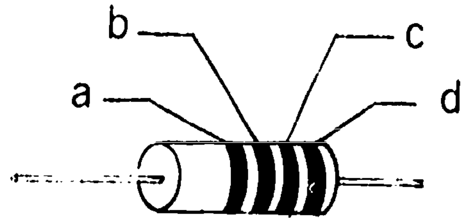
(3)

12. When reading a resistor's ohmic value, one has to start at the:

___ a. end of the resistor with the most body color showing.
___ b. band closest to the end of the resistor.
___ c. band farthest from the end of the resistor.

(b) band closest to the end of the resistor

13.



Match the lettered bands in the illustration to their correct meanings.

___ 1. first significant figure.
___ 2. second significant figure.

(1. d; 2. c)

14. Assume that a resistor has an ohmic value of 45,000 ohms.

a. What number is represented by the first band? ____
b. What number is represented by the second band? ____
c. What is the first significant figure? ________
d. What is the second significant figure? ________

(a. 4; b. 5; c. 4; d. 5)

15. We said that the actual numerical values assigned to the bands on a resistor are determined by their color. The following table lists the colors used for the bands and their corresponding values. Refer to this table in answering frames 16 to 22.

COLOR	SIGNIFICANT FIGURE	DECIMAL MULTIPLIER	RESISTANCE TOLERANCE
Black	0	1	---
Brown	1	10	---
Red	2	100	---
Orange	3	1,000	---
Yellow	4	10,000	---
Green	5	100,000	---
Blue	6	1,000,000	---
Violet	7	10,000,000	---
Gray	8	100,000,000	---
White	9	1,000,000,000	---
Gold	---	.1	$\pm$ 5%
Silver	---	.01	$\pm$ 10%
No color	---		$\pm$ 20%

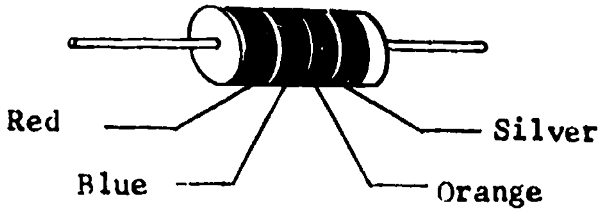
---

16. If a resistor's ohmic value is 4300 ohms, what will the colors be for the first and second significant figures?

a. First significant figure: ________
b. Second significant figure: ________

(a. yellow; b. orange)

17. What are the values of the first and second significant figures?



a. 1st significant figure: ____________
b. 2nd significant figure: ____________

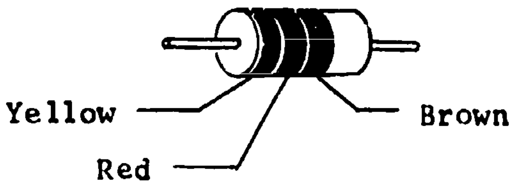
- -

(a. 2; b. 6)

18. The third band is called the decimal multiplier and indicates the number by which the first and second significant figures must be multiplied to obtain the ohmic value of the resistor. For example, if the first two digits of a resistor are 26, and the color of the third band is orange, it must be multiplied by 1000, giving the resistor an ohmic value of 26,000 ohms or 26kΩ (26 x 1000 = 26,000Ω).

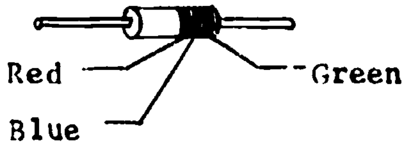
What are the ohmic values of each of the following resistors?

a.



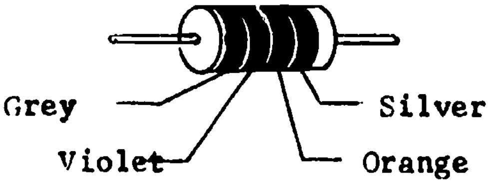
________Ω

b.



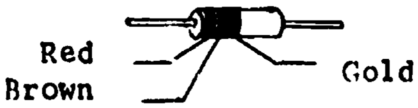
________Ω

c.



________Ω

d.



________Ω

- -

(a. 420Ω; b. 5600Ω; c. 87,000Ω; d. 2.1Ω)

19. The most convenient way of dealing with the multiplier band is not to think of it in terms of actual multiplication by .0, 100, 1000, etc., but merely as an indication of how many zeros to add after the first two digits. For example, if the multiplier band is red, it means add two zeros; if it is white, add nine zeros.

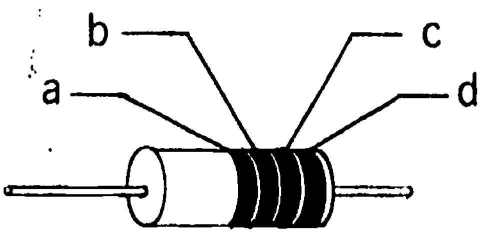
Each of the following represents the first three colored bands of a resistor. Using only the color code table on the right, determine the ohmic value of each resistor.

a. Brown-Red-Yellow ___ Ω
b. Yellow-Orange-Red ___ Ω
c. Violet-Red-Orange ___ Ω
d. Blue-Brown-Green ___ Ω

Color	Significant Figure
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9
Gold	---
Silver	---
No color	---

(a. 120,000Ω or 120kΩ; b. 4,300Ω or 4.3kΩ; c. 72,000Ω or 72kΩ; d. 6,100,000Ω or 6.1MΩ)

20.



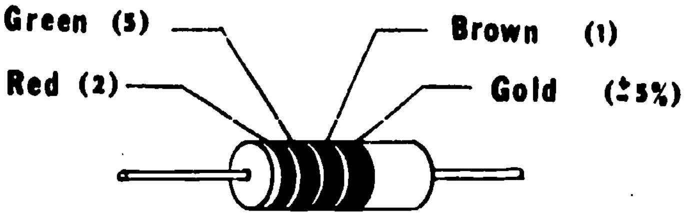
Match the lettered bands to their meaning.

___ 1. first significant figure
___ 2. second significant figure
___ 3. decimal multiplier

(1. d; 2. c; 3. b)

21. The resistance value obtained by reading the first three bands of a resistor is seldom exact. For this reason, a fourth band is used to determine how accurately the resistor was manufactured. This band shows the resistor's tolerance as a percentage of the resistor's value. For example, a 100Ω resistor with a silver band indicates a 10% tolerance. This means that the ohmic value of the resistor will vary plus or minus 10 percent of 100Ω, that is, the ohmic value will range from 90Ω to 110Ω.

What is the range of possible values?



____Ω to ____ Ω

(237.5Ω to 262.5Ω)

22. Match:

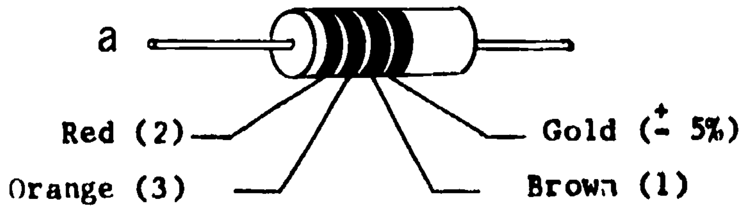
___ 1. No color	a.	20%
___ 2. Gold	b.	5%
___ 3. Silver	c.	10%

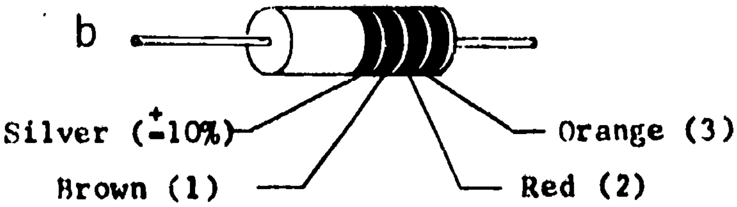
(1. No color - 20%; 2. Gold - 5%; 3. Silver - 10%)

23. Match each resistor to its correct ohmic value.

___ 1. 230 ± 5%

___ 2. 320 ± 10%





(1. a; 2. b)

24. The color code has been broken down into a sentence to aid in remembering it. The first letter in each word will represent the first letter in a color. The sentence is: Bad Boys Race Our Young Girls Behind Victory Garden Walls. Get Started Now.

Put the booklet aside and repeat the words to yourself several times; then proceed to the next frame.

(Go to next frame.)

25. Now let's assign colors and numbers to each of the words.

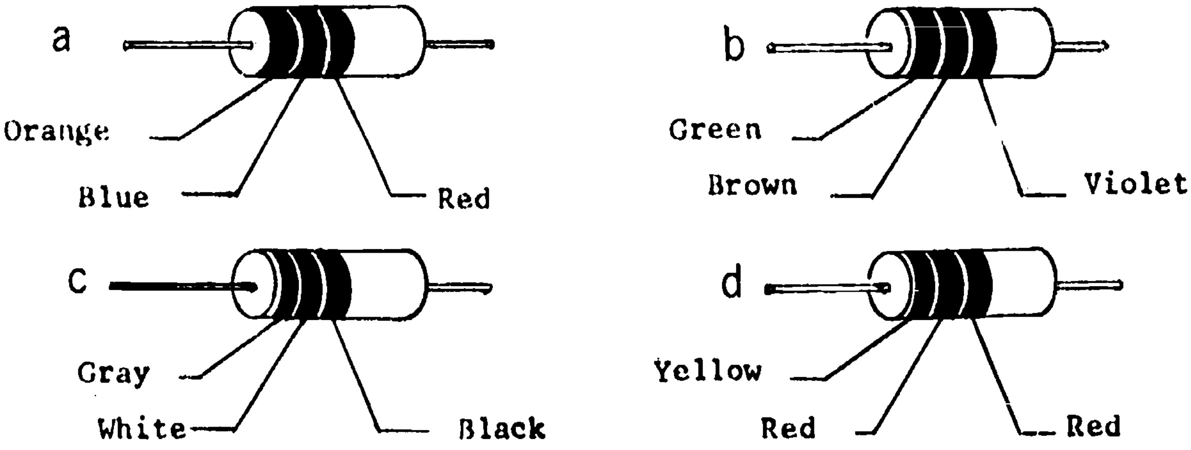
Bad	Black	0
Boys	Brown	1
Race	Red	2
Our	Orange	3
Young	Yellow	4
Girls	Green	5
Behind	Blue	6
Victory	Violet	7
Garden	Gray	8
Walls	White	9
Get	Gold	.1
Started	Silver	.01
Now	No Color	---

There is no significant figure for gold, silver, or no color; however, gold and silver represent the decimal multipliers .1 and .01 respectively.

Study frames 24 and 25 until you have the sequence of colors and numbers memorized. Then write the sentence, colors, and numbers on a separate sheet of paper before continuing.

(Go to next frame)

26. Determine the ohmic values of the following resistors:



a. ____________ Ω c. ____________ Ω

b. ____________ Ω d. ____________ Ω

- -

(a. 3,600Ω or 3.6kΩ; b. 510,000,000Ω or 510MΩ; c. 89Ω; d. 4,200Ω or 4.2kΩ)

27. Place the significant figure (0-9) next to the appropriate color.

____ a. gray
____ b. white
____ c. black
____ d. red
____ e. green
____ f. yellow
____ g. blue
____ h. orange
____ i. brown
____ j. violet

- -

(a. 8; b. 9; c. 0; d. 2; e. 5; f. 4; g. 6; h. 3; i. 1; j. 7)

28. As was mentioned earlier, the easiest way of dealing with the decimal multiplier is to determine what figure that color represents, then add that number of zeros to the first two digits. If the third band were yellow you would add ______ zeros; this would be the same as multiplying by ______.

- -

(4; 10,000 or 10^4)

29. Match the decimal multiplier to the appropriate color.

___ 1. green	a.	1,000
___ 2. red	b.	1,000,000,000
___ 3. black	c.	.01
___ 4. gray	d.	10
___ 5. brown	e.	100,000
___ 6. violet	f.	100,000,000
___ 7. silver	g.	10,000
___ 8. blue	h.	.1
___ 9. gold	i.	1,000,000
___ 10. Yellow	j.	10,000,000
___ 11. orange	k.	100
___ 12. white	l.	1

- -

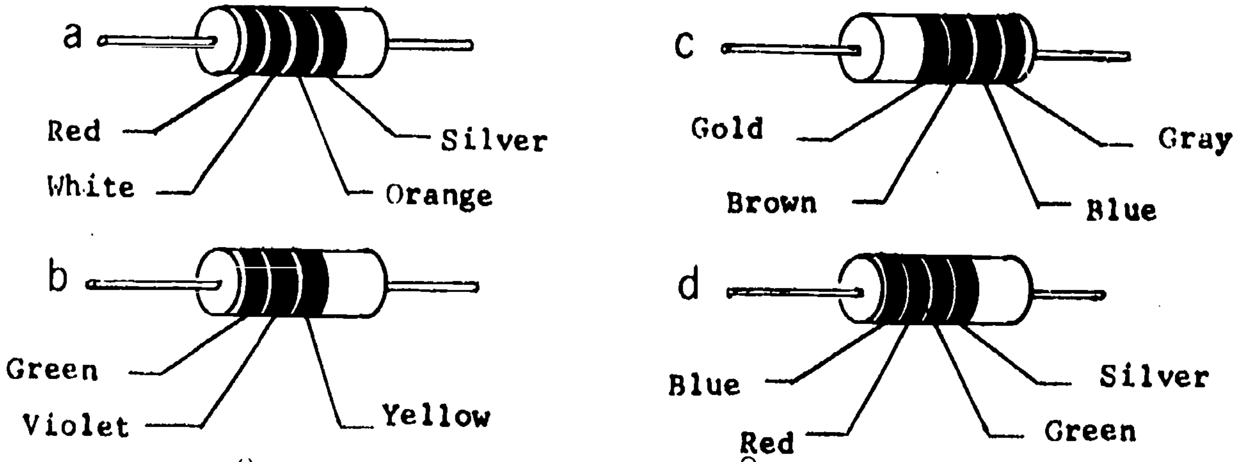
(1. e; 2. k; 3. l; 4. f; 5. d; 6. j; 7. c; 8. i; 9. h; 10. g; 11. a; 12. b)

30. The fourth band is used to indicate the tolerance. The colors that will be used for the fourth band are:

Get	Gold	5%
Started	Silver	10%
Now	No Color	20%

In the case of no color, there will simply be no fourth band and you will assume 20% tolerance.

Determine the ohmic value and tolerance for each resistor.



a. ______Ω c. ______Ω

b. ______Ω d. ______Ω

- -

(a. 29,000Ω $\pm$ 10% or 29kΩ $\pm$ 10%; b. 570,000Ω $\pm$ 20% or 570kΩ $\pm$ 20%; c. 860Ω $\pm$ 5%; d. 6,200,000Ω $\pm$ 10% or 6.2MΩ $\pm$ 10%)

31. Write the correct tolerance values for each of the following colors.

___ a. no color
___ b. gold
___ c. silver

(a. 20%; b. 5%; c. 10%)

32. Determine the value and tolerance for each resistor in your power supply.

a. T1 - T2 ______ Ω ± ______ %
b. T3 - T4 ______ Ω ± ______ %
c. T4 - T5 ______ Ω ± ______ %
d. T5 - T6 ______ Ω ± ______ %

(a. 4.7Ω ± 10%; b. 4.7Ω ± 10%; c. 1kΩ ± 10%; d. 1kΩ ± 10%)

33. Get Resistor Practice Board 3-2 from the resources center and fill in the following table for the resistors on the board.

Resistor #	Value	Tolerance
R1		
R2		
R3		
R4		
R5		

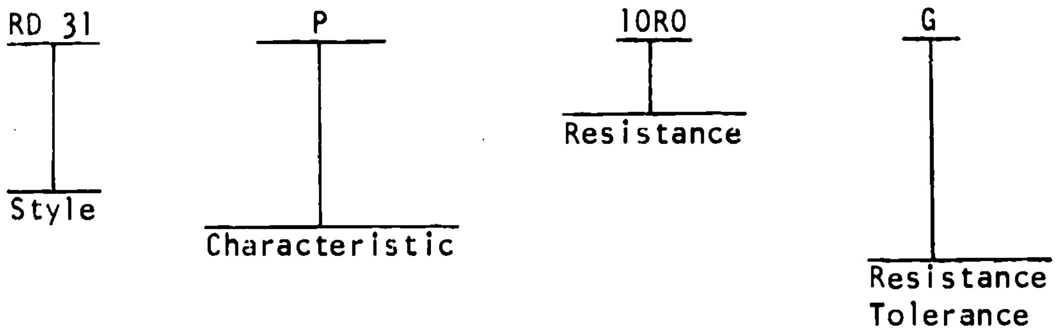
(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN ON THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 33

TURN RESISTOR PRACTICE BOARD 3-2 OVER AND CHECK YOUR ANSWERS WITH THOSE ON THE BACK OF THE BOARD.

IF YOUR ANSWERS ARE CORRECT, YOU MAY GO ON TO TEST FRAME 43. OTHERWISE, GO BACK TO FRAME 7 AND TAKE THE PROGRAMMMED SEQUENCE BEFORE TAKING TEST FRAME 33 AGAIN.

34. In addition to the Color Coded method, resistors are identified in the following form in accordance with established military specifications for electronic and communication type equipments:



The above resistor part-numbering system is established by ________________.

(military specifications)

35. The following explains the meaning of the letters and numbers in the coded group: RD31P10R0G.

RD31 (Style): The first two digits represent the type of resistor such as Fixed Wire-wound, Variable Wire-wound, Fixed Composition; etc. The next two digits represent size, power rating, configuration, etc., dependent upon the type of resistor.

P (Characteristic): A letter that indicates temperature characteristics of the resistor.

10R0 (Resistance Value): This is the most important part of the coded group. It may have as many as five digits or as few as 3 to indicate the ohmic value of a resistor. (More about this later.)

G (Resistance Tolerance): A letter that indicates the limits of the resistance value.

In the example of military specifications resistor part-numbering below, indicate the meaning of each section.

RB09	A	12501	F
______	______	______	______

(RB09-Style; A-Characteristic; 12501-Ohmic Value; F-Tolerance)

(NOTE: Due to the large numbers of possibilities existing for Style, Characteristic and Tolerance, these values will not be covered in any greater detail. If further information is desired, consult Electronics Installation and Maintenance Book, pages 3-244 through 3-256.)

36. Now, let's take a closer look at Resistance Magnitude.

Starting with a three digit-number: 103
1. The first two digits are significant figures: 10
2. The third digit indicates the number of zeros to be added to the significant figures: 10,000

Thus we have 10,000 ohms or 10 kilohms.

What is the resistance of the resistor below? ______________

(150,000Ω)

37. In addition to the three numerical digits, you may see one with an R in it--like so:

5R0

The R represents a decimal point and is used when indicating values of resistance less than 10 ohms and/or fractions of an ohm. The example, then, represents 5 ohms or more specifically 5.0 ohms.

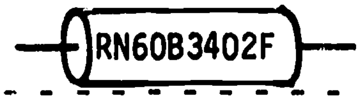
What is the resistance of the below resistor? ________________.

(4.0Ω)

38. Now, on to the four-digit indicator: 1003

1. The first three digits represent significant figures: 100
2. The fourth digit represents the number of zeros to be added: 100,000

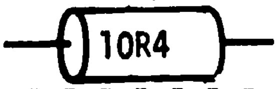
Determine the resistance of the below resistor. ____________



(34,000Ω)

39. Here, too, an R may be used to represent a decimal point and will be used to indicate ohmic values of less than 100 ohms and of fractions of ohms.

What resistance value is represented by: ________________



(10.4Ω)

40. The five-digit representation is similar to the three- and four-digit. The first four digits represent significant figures while the last digit indicates the number of zeros to be added. For values of less than 1000 and for fractional parts of an ohm the R is used to designate a decimal point.

What is the resistance value of a resistor marked? ____________

(12,500Ω)

41. Let's run over all three again.

1. The three-digit has __________ significant figures and the last digit indicates ____________ to be added.

2. The four-digit has ____________ significant figures and the ___________ indicates the number of zeros to be added.

3. The five-digit has ____________ significant figures and the ___________ digit indicates the number of zeros to be added.

4. Last but not least - each system may have an R which represents a/an ________________.

(1. two, number of zeroes; 2. three, last digit; 3. four, last; 4. decimal point)

42. Indicate the meaning of each section of the Military Specifications resistor part number below:

RB09 A 105 G

(style - characteristic - value - tolerance).

43. Determine the value of resistance for each of the below resistors.

1. 

2. 

3. 

4. 

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN ON THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 43

1. 10 kΩ

2. 350 kΩ

3. 55.2Ω

4. 5.0Ω

- -

IF ANY OF YOUR ANSWERS IS <u>INCORRECT</u>, GO BACK TO FRAME 34 AND TAKE THE PROGRAMMED SEQUENCE.

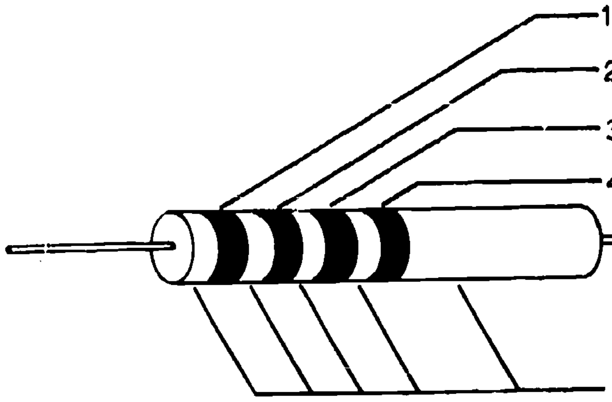
IF YOUR ANSWERS ARE CORRECT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL THE QUESTIONS CORRECTLY, GO ON TO THE NEXT LESSON. IF NOT, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

SUMMARY
LESSON III

Resistor Identification

The unit of measure of resistance is the ohm, represented by the Greek letter omega (Ω). Metric prefixes commonly used with ohm are kilo- and mega-. One ohm is defined as the amount of resistance which permits 1 ampere of current flow when 1 volt is applied across it.

The value of a carbon resistor is usually indicated by bands of color painted on the resistor like this:



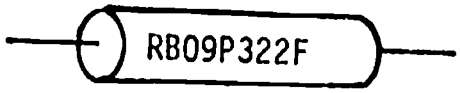
The first band of color indicates the first significant number of the resistance value, the second band tells the second digit, and the third band indicates the multiplier (power of ten) to be used. The fourth band indicates the tolerance of the resistor's value.

The color used in marking resistors and the numbers they stand for are shown in the table below:

Color	Significant Figure	Decimal Multiplier	Resistance Tolerance Percent ±
Black	0	1	---
Brown	1	10	---
Red	2	100	---
Orange	3	1000	---
Yellow	4	10,000	---
Green	5	100,000	---
Blue	6	1,000,000	---
Violet	7	10,000,000	---
Gray	8	100,000,000	---
White	9	1,000,000,000	---
Gold	---	.1	5
Silver	---	.01	10
No color	---		20

A resistor marked orange, white, green, and gold would have 39×10^5 ohms with a tolerance of $\pm$ 5%. The <u>no color</u> listing in the table means that if the resistor has no fourth color band, its tolerance is $\pm$ 20%. (NOTE: When the <u>third</u> band (decimal multiplier) is gold or silver, the ohmic value of a resistor should be less than 10 ohms.)

In addition to the color code, resistors are sometimes identified by a Part Numbering System.



RB09	P	322	F
Style	Characteristic	Resistance Value	Tolerance

The number we are primarily interested in is the one indicating the resistance value. The value of resistance may be indicated by three, four, or five digits.

In each case, the last digit dictates the number of zeros to be added to the significant figure represented by the first two, three, or four digits. For the example shown, <u>32</u> represents the first two significant figures, while the third number (2) tells how many zeros to add. So 322 indicates 3200 ohms. If a decimal point is required to specify the value of a precision resistor, an <u>R</u> is used to represent the decimal point. As an example: <u>472.5</u> Ω would be indicated as <u>472R5</u>.

The amount of power a carbon resistor can dissipate is usually dependent on its physical size. The larger resistors have more surface area and can transfer heat to the air around them more quickly than smaller resistors.

If you wish to learn more about resistors, continue with another part of Lesson III. If not, get Resistor Display Board 2 and fill in the table in the Narrative for Lesson III.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK, OR YOU MAY STUDY THE LESSON NARRATIVE OR THE PROGRAMMED INSTRUCTION OR BOTH. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, GO TO THE NEXT LESSON. IF NOT, STUDY ANOTHER METHOD OF INSTRUCTION UNTIL YOU CAN ANSWER ALL THE QUESTIONS CORRECTLY.

BASIC ELECTRICITY AND ELECTRONICS

INDIVIDUALIZED LEARNING SYSTEM

MODULE THREE

LESSON IV

The Ohmmeter

Study Booklet

OVERVIEW
LESSON IV

The Ohmmeter

In this lesson, you will study and learn about the following:

- -description of a multimeter
- -the meter face
- -rules for use
- -reading resistance
- -practical ohmmeter use
- -ohmmeter uses

Each of the above topics will be discussed in the order listed. As you proceed through this lesson, observe and follow directions carefully.

BEFORE YOU START THIS LESSON, PREVIEW THE LIST OF STUDY RESOURCES ON THE NEXT PAGE.

LIST OF STUDY RESOURCES

LESSON IV

The Ohmmeter

To learn the material in this lesson, you have the option of choosing, according to your experience and preferences, any or all of the following:

STUDY BOOKLET:

Lesson Narrative

Programmed Instruction

Lesson Summary

ENRICHMENT MATERIAL:

NAVPERS 93400A-1a "Basic Electricity, Direct Current." Fundamentals of Electronics. Bureau of Naval Personnel. Washington, D.C.: U.S. Government Printing Office, 1965.

AUDIO-VISUAL:

Sound/Slide Presentation - "Measurement of Resistance--The Ohmmeter."

You may study whatever learning materials you feel are necessary to answer the questions in the Lesson Progress Check. All your answers must be correct before you can go on. Remember, your instructor is available at all times for any assistance you may need.

YOU MAY NOW STUDY ANY OR ALL OF THE RESOURCES LISTED ABOVE. YOU MAY TAKE THE PROGRESS CHECK AT ANY TIME.

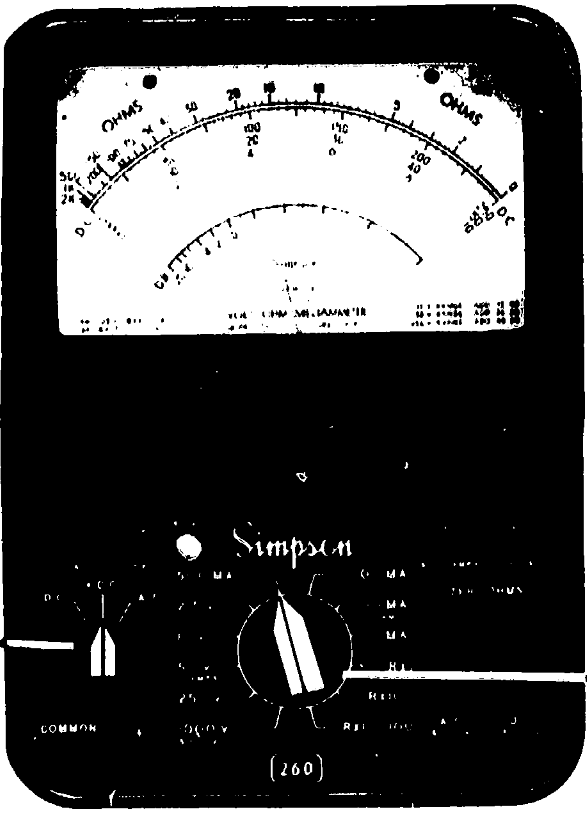
NARRATIVE
LESSON IV

The Ohmmeter

Description

The device which is used to measure resistance is called an ohmmeter. The schematic symbol we will use for this meter is a circle around the Greek letter omega (Ω). In this course, we will not use a simple ohmmeter but a multimeter. A multimeter is just what its name implies; it is a meter which can be used for more than one purpose. The multimeter used here is the Simpson model 260-5P meter which can measure a wide range of AC and DC voltages and DC current, as well as resistance. Here is a picture of the face and controls of the 260-5P multimeter.

Function Switch



Range Selector

There are three resistance ranges on the Simpson model 260-5P multimeter, R x 1, R x 100, and R x 10,000. All the R ranges use the top markings on the meter. With the R x 1 range selected, the resistance values are read directly from this scale. (Note that these numbers read from right to left, not left to right.)

When the switch is turned to R x 100, all the values read from the scale must be multiplied by 100 (add two zeros); for the R x 10,000 range, four zeros must be added to each number. The three meter ranges are included to allow you to read over a greater range of resistance values. Generally, it is best to use a meter range which causes the pointer to rest over the center two-thirds of the scale, for the values can be more easily and accurately read in this area. The R x 1 range can be used accurately from 0 to about 200 ohms, the R x 100 range from roughly 20 to 20,000 ohms, and the R x 10,000 range is useful from 2,000 to 2,000,000 ohms.

Rules for Use

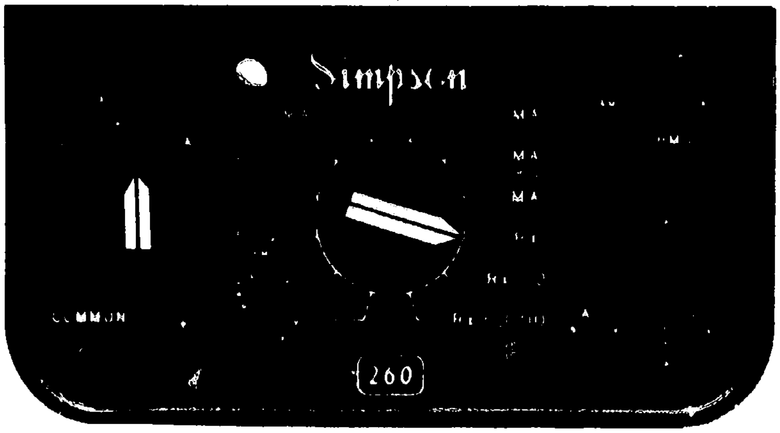
Whenever you take a reading from a meter, be sure you are directly in front of the meter face. If you read the meter at an angle, you will read an incorrect value, for the pointer will seem either higher or lower than it actually is. This rule applies to any kind of meter reading you may make.

An ohmmeter, like any other meter, can be damaged by too much current flow. The ohmmeter requires even more care than an ammeter or voltmeter, however, for it has a voltage source inside it and can be more easily overloaded. For this reason, never connect an ohmmeter into an energized circuit. Always make certain that whatever you are measuring has no electricity applied to it.

The ohmmeter must be "zeroed" each time the range is changed. This must be done to compensate for differences in the characteristics of the battery and test leads used in the meter. Not only is each battery slightly different, but batteries also change as they age.

To ensure accurate readings, you must perform these steps when you first use an ohmmeter and each time you change the range.

1. Connect a red test lead to the "+" jack and a black test lead to the common (-) connector.
2. Set the function switch (left-hand knob) to "+DC."
3. Turn the range selector (middle knob) to the desired setting.
4. Hold the probes so that the metal tips make good contact with each other.
5. Turn the "Zero Ohms" control (right-hand knob) to get a zero reading on the meter. Remember to look at the meter from a position straight in front of it. If your meter will not "zero" take it to your instructor.
6. The ohmmeter is now zeroed; separate the leads so you will not waste the battery's energy.



Reading Resistance

Resistance readings are made as follows:

1. Connect the test probes to the meter: (red to "+" and black to common (-).
2. Zero the meter (see last page if your memory needs a push). If you don't know what reading to expect, start on the R x 1 scale and change scales later if necessary.
3. Make certain there is no voltage present at the points you are going to measure.
4. Place the test probes on the points between which you wish to measure (ends of resistor, etc.).
5. Read the resistance on the top meter scale. If the pointer is too far to the left, change to a higher resistance scale; zero the meter again. Then repeat steps 4 and 5.
6. Multiply this reading by the value indicated on the range switch.
7. Turn the range switch to the 1,000-volt scale. This prevents discharge of the battery when the ohmmeter is not in use and also protects the meter from damage if someone carelessly uses it without first checking the switch positions.

Ohmmeter Experiment

Practice using the ohmmeter by measuring the values of the resistors on Practice Board 3-2. Compare your readings to the values indicated by the color code on the resistors.

Resistor #	Value	Tolerance
1.		
2.		
3.		
4.		
5.		

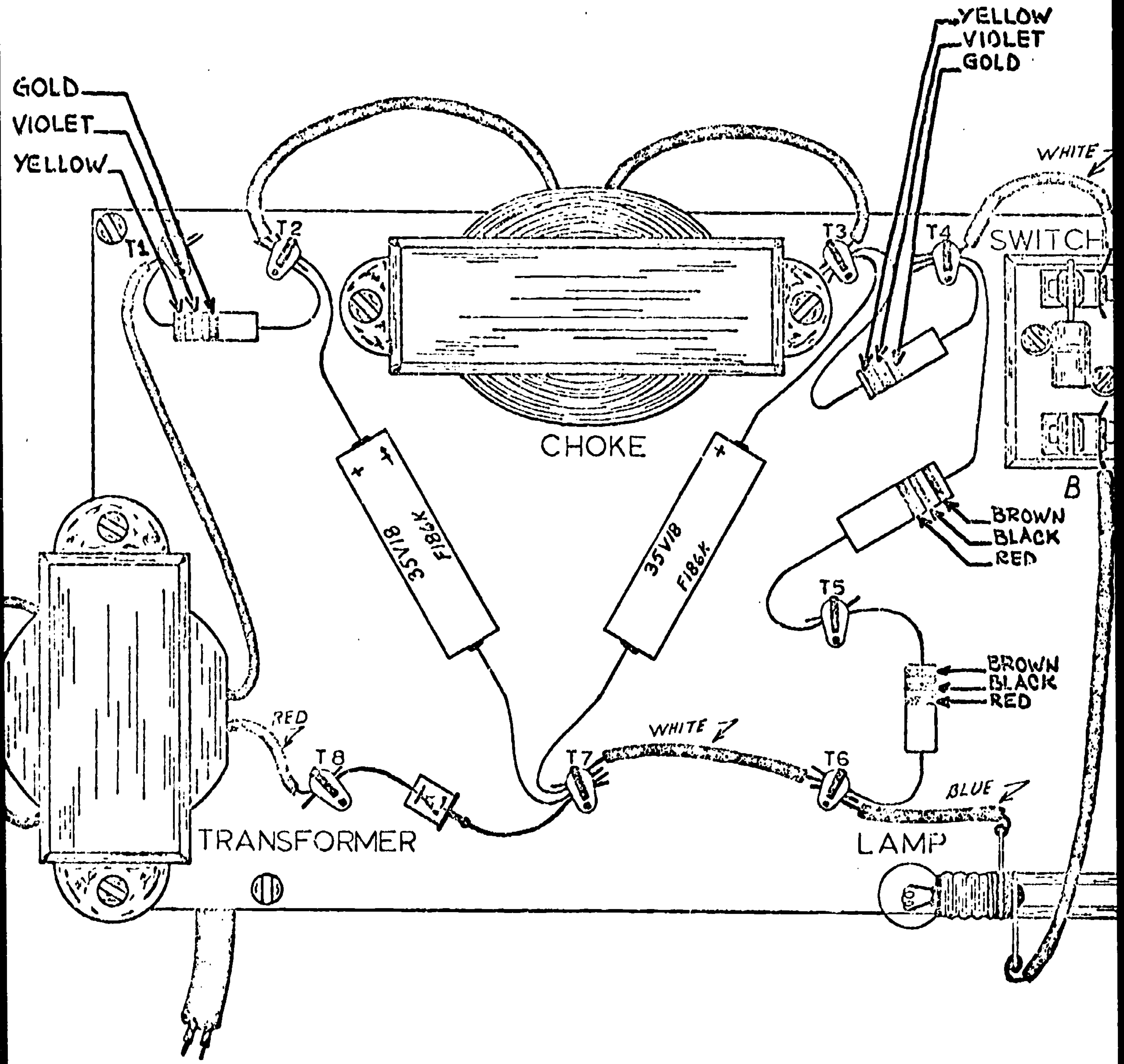
TURN BOARD OVER AND CHECK YOUR ANSWERS.

Ohmmeter Uses

An ohmmeter can do much more for you than just check whether a resistor has gone bad. It can check circuit continuity, locate defective components, and help determine which section of a complex circuit is causing trouble.

If the lamp in your power supply fails to light with the power supply plugged in and the switch closed, we would check continuity of the circuit to locate the cause of the problem.

The most probable cause of trouble is an open circuit. An open circuit is like an open switch, that is, there is no path for current flow. Before using the ohmmeter, unplug the power supply so there will be no voltage in the circuit. Refer to diagram on next page.


GOLD
VIOLET
YELLOW
T1
T2
CHOKE
T3
T4
YELLOW
VIOLET
GOLD
WHITE
SWITCH
B
BROWN
BLACK
RED
T5
BROWN
BLACK
RED
35V18
F186K
35V18
F186K
TRANSFORMER
RED
T8
T7
WHITE
T6
BLUE
LAMP

To find the location of the open, first isolate the lamp circuit by disconnecting the lamp at T6. Set your meter to the R x 1 scale and zero the meter. Check again to be very certain the power cable for the power supply is not plugged in. Open the switch to simulate an open circuit. Place one meter lead at T4 and the other on the end of the wire you removed from T6. The ohmmeter will read infinity (∞), indicating that no current can flow in the circuit. It was necessary to disconnect the wire from T6 so that the resistors between T4 and T6 would not affect your reading. This confirms that there is an open circuit.

Now close the switch. The meter should deflect toward 1 ohm, indicating there is now a path for current flow.

Next, loosen the lamp; this will produce the same results as would a burned-out lamp. Once again, read the resistance from T4 to the end of the wire you removed from T6. You should read infinity; if not, unscrew the light bulb until you do read infinity. This time, check point by point to find the open portion of the circuit. You can start with any part of the circuit to make continuity checks, but it will usually be faster to divide it in half and work from there. Measure between point B of the switch and T4. The meter deflection shows that there is a continuous path for current between these points, so the trouble must be somewhere between T6 and point B of the switch. Now measure between T6 and terminal A of the lamp. The meter pointer does not move, so the open must be between these points. Measuring the resistance of the wire from T6 to B of the lamp indicates continuity, and the lamp and lamp socket are all that is left. A check of the resistance from A to B of the lamp socket will verify that the open has been located.

You can locate any open in a circuit with an ohmmeter and a procedure like this one.

AT THIS POINT YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, YOU HAVE MASTERED THE MATERIAL AND ARE READY TO TAKE THE MODULE TEST. SEE YOUR INSTRUCTOR.

IF YOU DECIDE NOT TO TAKE THE PROGRESS CHECK AT THIS TIME, OR IF YOU MISSED ONE OR MORE QUESTIONS, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU HAVE ANSWERED ALL THE PROGRESS CHECK QUESTIONS CORRECTLY. THEN SEE YOUR INSTRUCTOR AND ASK TO TAKE THE MODULE TEST.

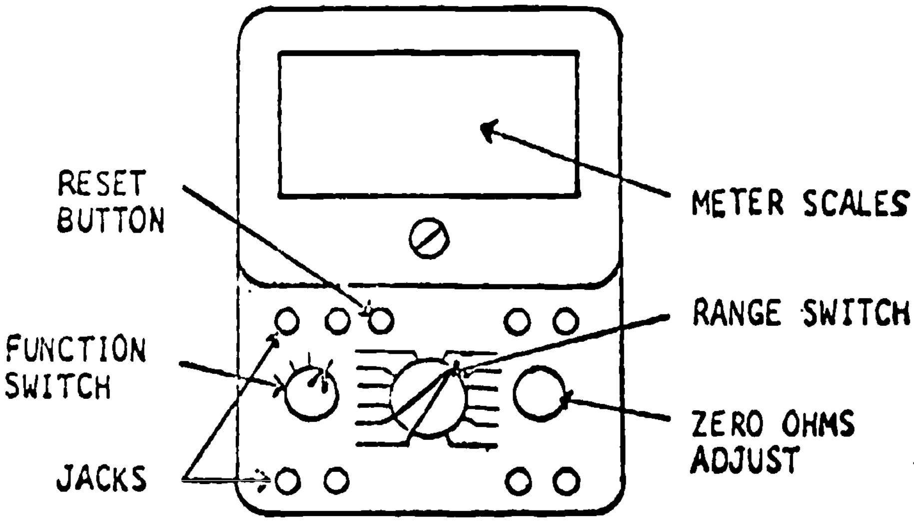
PROGRAMMED INSTRUCTION
LESSON IV

The Ohmmeter

TEST FRAMES ARE 16, 23, AND 43. AS BEFORE, GO FIRST TO TEST FRAME 16 AND SEE IF YOU CAN ANSWER ALL THE QUESTIONS THERE. FOLLOW THE DIRECTIONS GIVEN AFTER THE TEST FRAME.

---

1. Using the illustration below, locate on your multimeter the six basic components and controls of the Simpson 260-5P.



- -

(Go on to Frame 2)

2. List the five different scales found on the meter face.

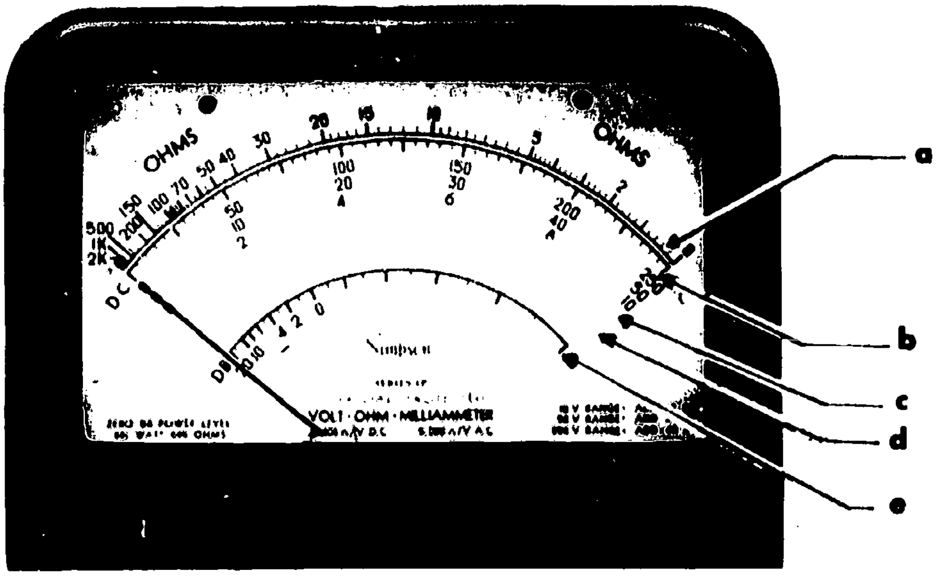
a. ______________________
b. ______________________
c. ______________________
d. ______________________
e. ______________________

- -

(a. ohm's scale; b. DC scale; c. AC scale; d. AC 2.5v scale; e. output scale- DB)

3. The scale used for resistance measurements is the ohm's scale located at the top of meter face.

   Which arrow points to the resistance scale?

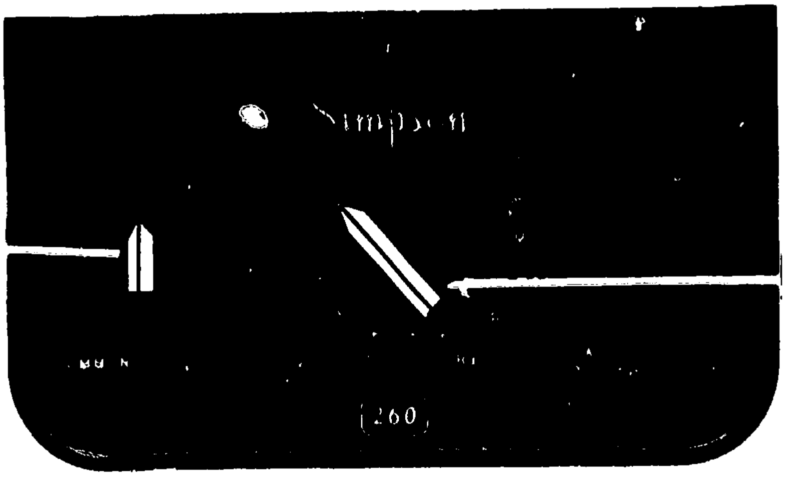


(a)

---

4. To facilitate the use of the multiscaled meter, the Simpson 260-5P is equipped with two major controls; these are the meter function switch and range switch. Using the illustration below, locate on the meter provided, the function switch and range switch.

FUNCTION SWITCH



RANGE SWITCH

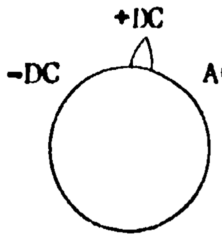
(Go on to next frame)

---

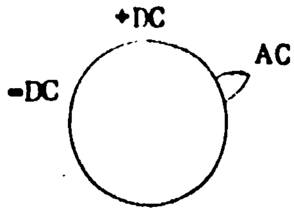
5. The function switch determines how the meter is to be used. For example, to measure AC voltage, the switch would be in the AC position. To measure DC current, DC voltage, or resistance the switch would be in either of the DC positions.

Which setting(s) could be used when measuring resistance?

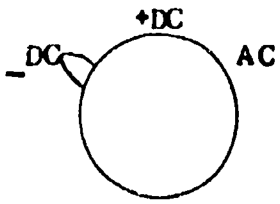
____ a



____ b



____ c

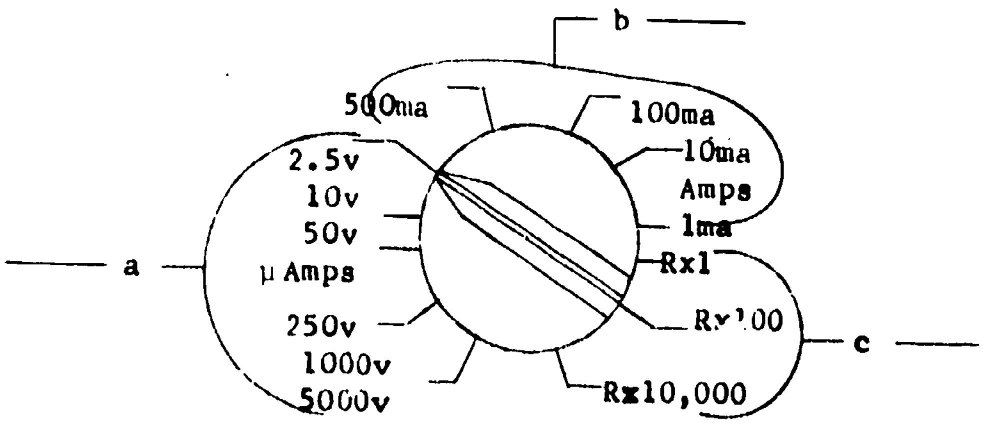


(a and c)

6. To measure direct current, resistance, or DC voltages, the function switch must be in the ________ or the ________ positions.

(+DC, -DC)

7. The range switch also determines whether the meter will be used as a voltmeter, ammeter, or ohmmeter. What range settings would be used when making a resistance measurement? ______________



- -

(c)

8. How many ranges are there for measuring resistance?

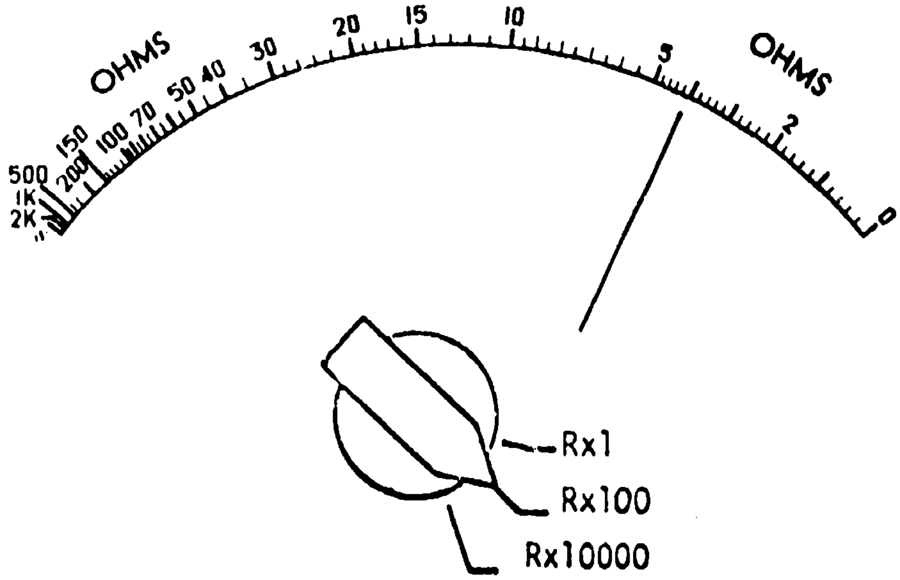
____

- -

(3)

9. When measuring resistance, the range switch will determine the multiplier. For example, if the switch is in the R x 10,000 position and the pointer indicates 15 on the meter face, the reading would be 150,000Ω (150KΩ).

What would the reading be for the illustration?



- -

(400Ω or 0.4KΩ)

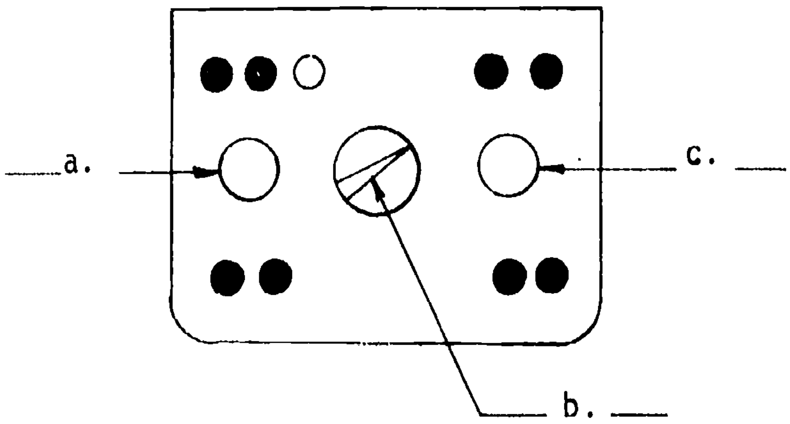
10. The third control, which is labeled 0 ohms, is used to ensure the meter's accuracy by compensating for aging of the meter's internal batteries, which are used during resistance measurements.

Locate the 0 ohms control on your meter.

- -

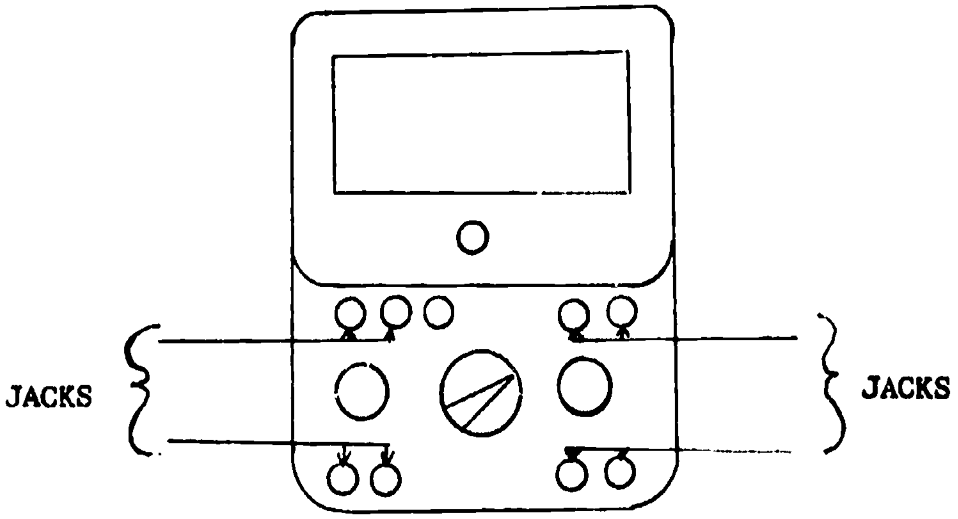
(Go to next frame)

11. Identify the zero ohms control. ______________



(c)

12. There are eight test lead jacks on the Simpson 260-5P. Using the illustration, locate the eight jacks on your meter.



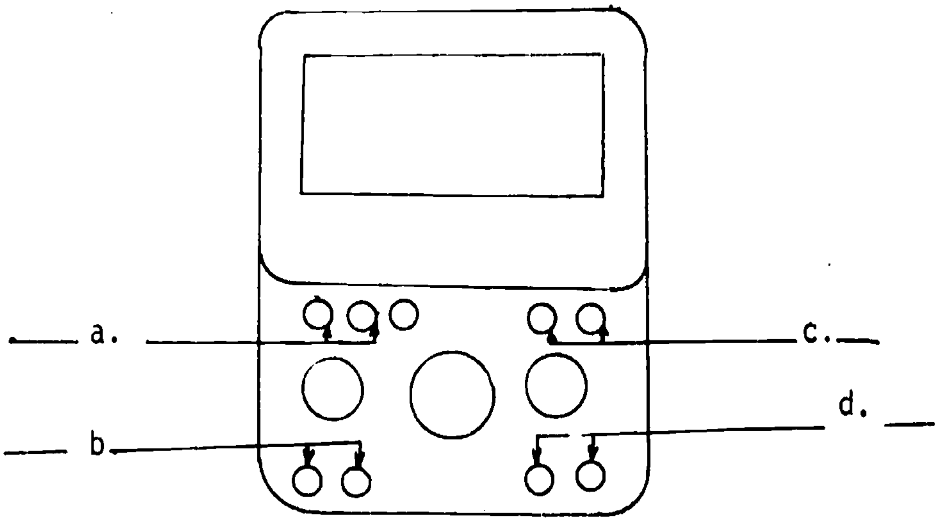
These test jacks will be used in conjunction with the red and black test leads provided.

(Go to next frame)

13. The jacks used for resistance measurements are marked common (-) and positive (+) and are located in the lower left-hand corner of the meter.

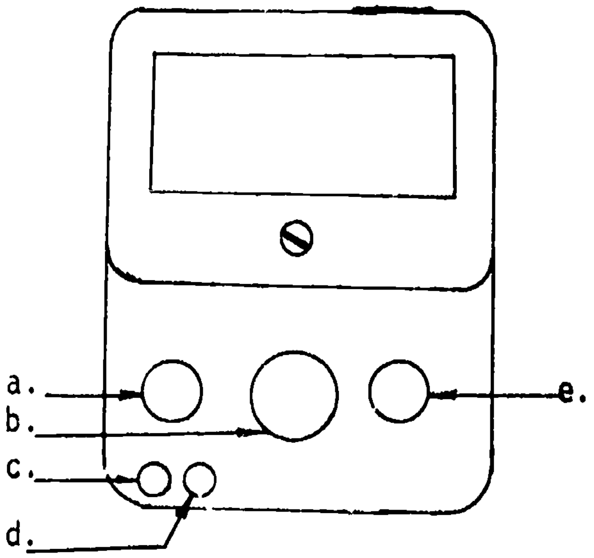
    Which arrow points to the jacks used when measuring resistance?

    ____



(b)

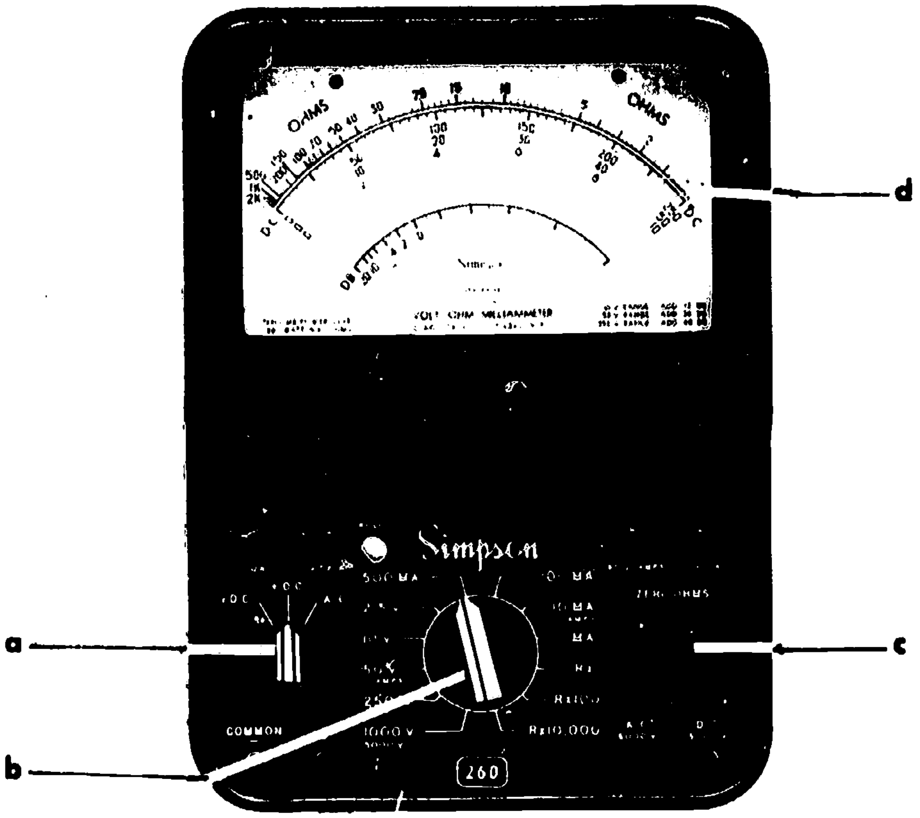
14. Match the letters to the multimeter components.



___ 1. range switch
___ 2. negative jack
___ 3. zero ohms control
___ 4. positive jack
___ 5. function switch

(1. b; 2. c; 3. e; 4. d; 5. a)

15. Match the letters to the functions.

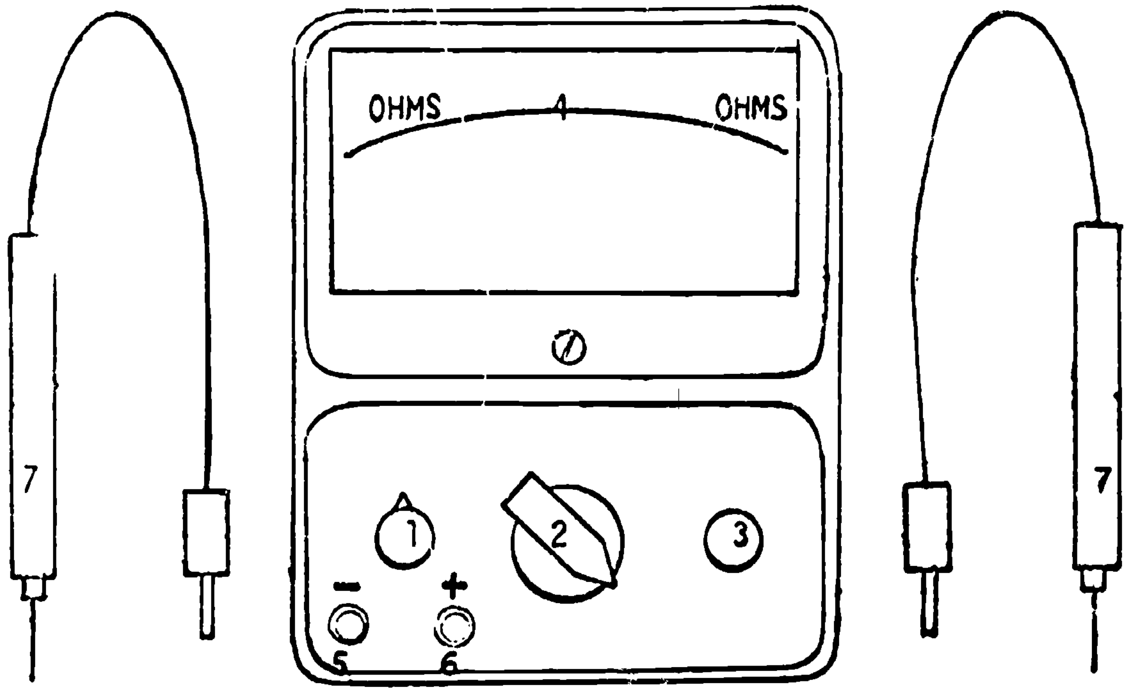


___ 1. determines multiplier
___ 2. must be adjusted before taking resistance measurements
___ 3. scale used for resistance measurements
___ 4. determines how meter will be used

(1. b; 2. c; 3. d; 4. a and b)

16. The illustration below shows the components and controls associated with the ohmmeter function of the Simpson 260-5P multimeter.

Study the illustration and the meter provided, then list the components and controls used when this multimeter is functioning as an OHMMETER.



1. ______________________ 5. ______________________

2. ______________________ 6. ______________________

3. ______________________ 7. ______________________

4. ______________________

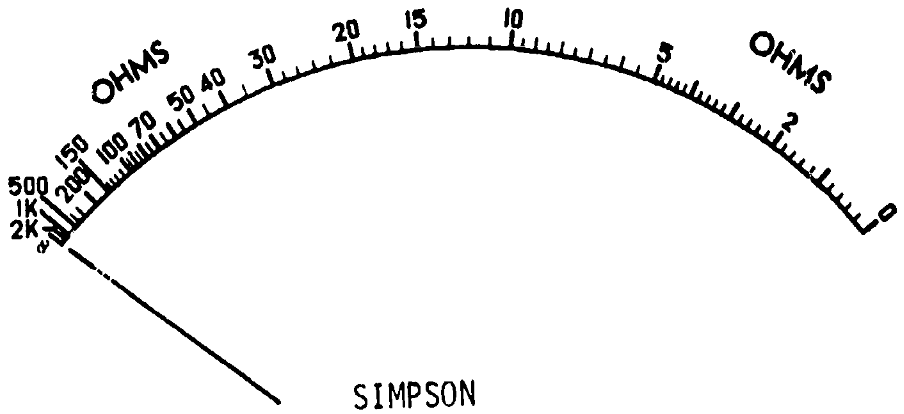
(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 16

1. function switch
2. range switch
3. zero ohms adjust
4. ohm's scale (resistance scale)
5. negative jack
6. positive jack
7. test probes (leads)

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 23. OTHERWISE, GO BACK TO FRAME 1 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 16 AGAIN.

17. The Simpson 260-5P utilizes the black scale at the top of the meter face when functioning as an ohmmeter.



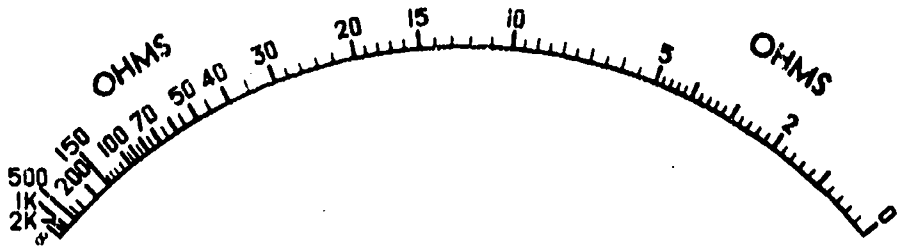
SIMPSON
260
SERIES 5
VOLT-OHM MILLIAMETER

Note that in relation to the other scales there are two outstanding differences. First the scale is reversed, that is, it reads from right to left.

If the pointer deflected all the way to the right, this would indicate ______________ resistance.

(0 or small)

18. Another difference between the ohm's scale and the other scales is that the increments (subdivisions) between the major scale divisions on the ohm scale are not equal across the entire scale. The scale is non-linear. The non-linearity becomes apparent when the values between the major divisions are compared.



For example, between 0 and 5 the increment values are equal to .2, that is, the scale reads ETC 1.4 1.2 1 .8 .6 .4 .2 0
Between 5 and 10, however, the values are equal to .5
ETC 7.5 7 6.5 6 5.5 5

What are the increment values between the major scale divisions listed below?

a. 10 to 20 ____________
b. 20 to 30 ____________
c. 30 to 100 ____________
d. 100 to 150 ____________
e. 150 to 200 ____________
f. 200 to 500 ____________
g. 500 to 1 K ____________
h. 1 K to 2 K ____________

(a. 1; b. 2; c. 5; d. 10; e. 50; f. 100; g. 500; h. 1,000)

19. If the pointer does not deflect from the left-hand side, this indicates either an extremely large or infinite (∞) resistance, as would be the case in an open circuit, or that the value of resistance in question is above the capabilities of the range setting. For example, in trying to measure a 2K ohm resistor on the R x 1 scale, the pointer would not deflect. In this case, you would move the range switch to the R x 100 position.

If no meter deflection is noted on the R x 100 position, you would ______________________.

(change to the R x 10,000. If no deflection occurs, you would assume the circuit to be open.)

20. Since accurate meter interpretations at the high end of the ohmic scale are impossible, the Simpson 260-5P multimeter is provided with three resistance ranges. The purpose of the three resistance ranges is to reduce the meter indication to an area on the meter scale where a more accurate reading can be taken. Each resistance position of the range switch is designed to be used with different resistance range measurements.

    The R x 1 range is used in measurements of 0 to 200 ohms.

    The R x 100 range is used in the measurements of 200 to 20 kilohms.

    The R x 10,000 range is used in the measurements of 20 kilohms and above.

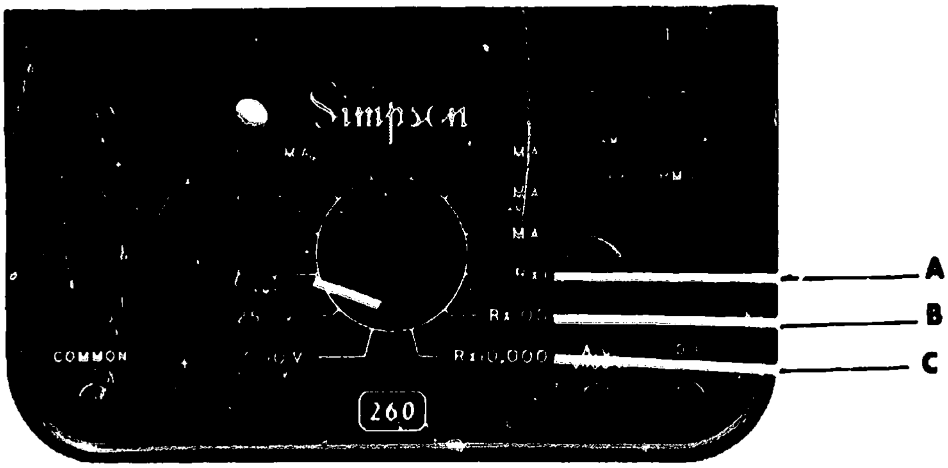
    What resistance range should be used with each of the resistance values listed below?

    a. 1600 ohms; R x ________
    b. 22 kilohms; R x ________
    c. 12 ohms; R x ________
    d. 1 megohm; R x ________

- -

(a. 100; b. 10,000; c. 1; d. 10,000)

21. Select by letter the setting that best covers each range shown.



___ 1. 0 to 200 ohms
___ 2. 20 kilohms to 2 megohms
___ 3. 200 ohms to 20 kilohms

- -

(1. A; 2. C; 3. B)

22. To interpret the circuit or component resistance from the meter indication, you simply multiply the meter indication by the value of the selected range switch position.

For example, the meter indicates 1.6 and the range switch is in the R x 100 position.

R x 100 or 1.6 x 100 = 160 ohms

What is the value of the measured resistance of the following meter indications and range switch settings?

METER INDICATION	RANGE SWITCH SETTING	RESISTANCE VALUE
a. 1.7	R x 10,000	________
b. 30	R x 100	________
c. 5.5	R x 1	________
d. .25	R x 10,000	________

(a. 17 kilohms; b. 3 kilohms; c. 5.5 ohms; d. 2.5 kilohms)

23. Complete the chart below with either the resistance value, the meter indication, or the range switch setting.

METER INDICATION	RANGE SWITCH SETTING	RESISTANCE VALUE
a. ________	R x 100	6 Kilohms
b. 55	________	550 Kilohms
c. 7.5	R x 10,000	________

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 23

a. 60

b. R x 10,000

c. 75 Kohms

IF ALL YOUR ANSWERS MATCH THE CORRECT ANSWERS, YOU MAY GO ON TO TEST FRAME 43. OTHERWISE, GO BACK TO FRAME 17 AND TAKE THE PROGRAMMED SEQUENCE BEFORE TAKING TEST FRAME 23 AGAIN.

---

24. The schematic symbol we will use to represent an ohmmeter is a circle with the Greek letter <u>omega</u> in the center.

Which of the following represents an ohmmeter?

___ a. a

___ b. R

___ c. V

___ d. Ω

___ e. I

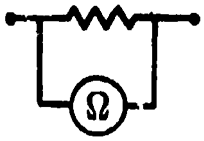
(d)

---

25. To measure resistance, the ohmmeter is connected in parallel or across the device to be measured.

Which is correct?

___ a. 

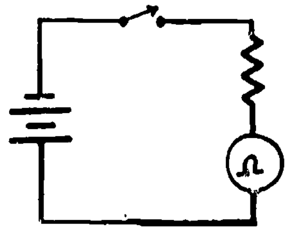
___ b. 

(b)

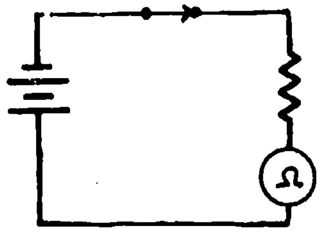
26. The multimeter, when used as an ohmmeter, uses its own internal power supply; consequently, an ohmmeter must never be connected into an energized circuit. This would result in extensive damage to the meter.

Which is correct for measuring resistance?

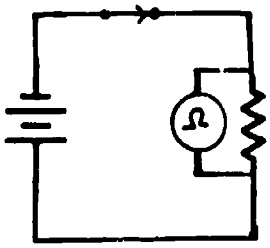
___ a.



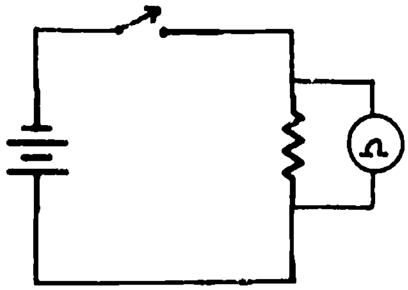
___ c.



___ b.



___ d.



- -

(d)

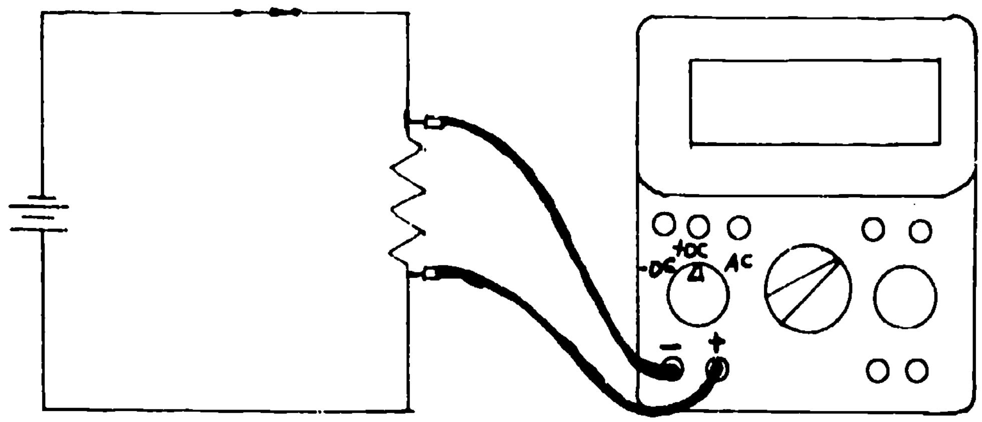
27. Before making a resistance measurement, the circuit must always be ____________________.

- -

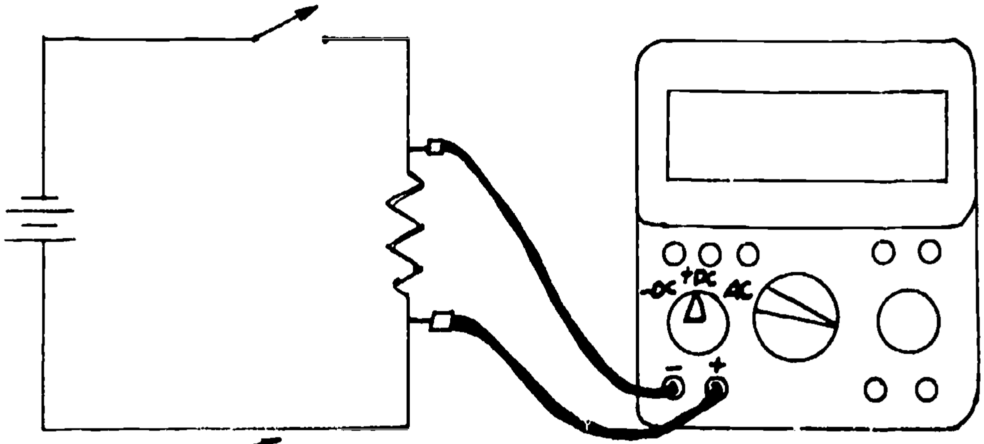
(de-energized)

28. Because the multimeter, when used as an ohmmeter, utilizes its own power supply, there is no need to observe polarity when measuring resistance. Which is correct for measuring resistance?

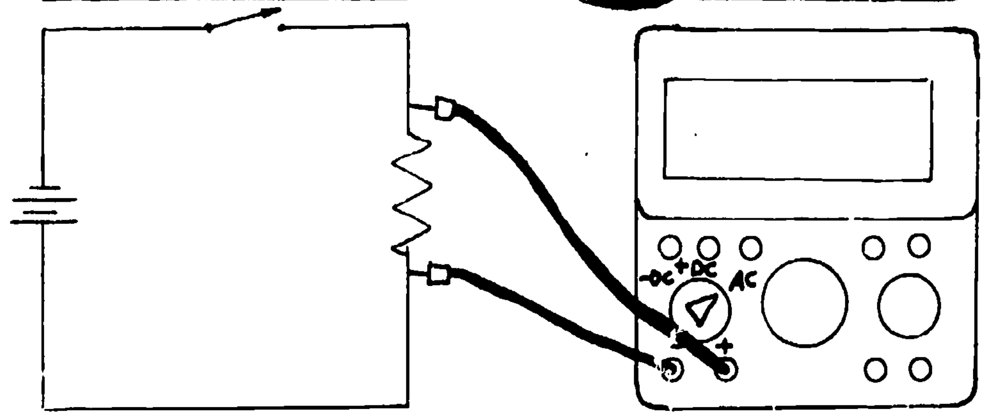
____ a.



____ b.



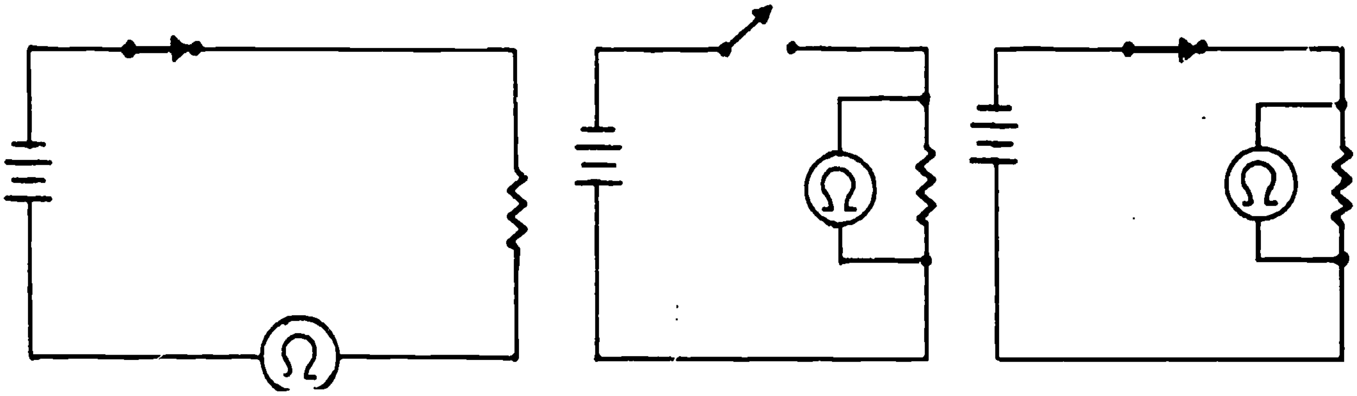
____ c.



(b)

29. Which illustration shows the correct method to measure R?

____ a. ____ b. ____ c.



(b)

30. Recall that the multimeter uses an internal power supply (batteries) when utilized as an ohmmeter. To compensate for variations in these batteries due to aging, the meter is equipped with a variable resistor, designated the Zero Ohms Control.

Listed below are the proper steps of procedure for checking the zero reference of the Simpson 260-5P multimeter.

1. Set the range switch at one of the resistance positions and the function switch at either of the DC positions.
2. Connect the black test lead in the common (-) jack and the red test lead in the (+) jack.
3. Clip the contact end of the test leads together to short out the resistance circuit.
4. Observe the meter indication. It should read 0 on the right end of the ohms arc.
5. If the pointer does not read 0, rotate the zero ohms control knob until it does. (If the meter will not zero, take it to your instructor.)
6. Unclip the shorted test leads. The ohmmeter is now ready to use.

To ensure an accurate reading, this procedure must be followed each time the range setting is changed. Utilizing these steps, check each of the resistance ranges on your meter.

(Go to next frame)

31. To make a resistance measurement:

1. set the function switch to either DC position.
2. set the range switch to any ______________ range.
3. connect the leads to the meter, black to the common (-) jack, red to the (+) jack.
4. "Zero" the meter.

<u>ALWAYS ENSURE THAT THE CIRCUIT IS DE-ENERGIZED.</u>

5. connect the leads across the device to be measured.
6. if the R x 10,000 range is too HIGH, the meter will read near zero; if this happens rotate the range selector switch to the next lower range and re-zero the meter.

(resistance)

32. Using the multimeter and a 27K-ohm resistor, measure its ohmic value and determine if it is within the allowable tolerance.

___ a. within tolerance
___ b. not within tolerance

(Go to next frame)

33. Draw Practice Board 3-2 from the resource center; measure and record the resistors' ohmic values. Compare your measurements with the values indicated by the color codes.

a. R1 ______________ ohms
b. R2 ______________ ohms
c. R3 ______________ ohms
d. R4 ______________ ohms
e. R5 ______________ ohms

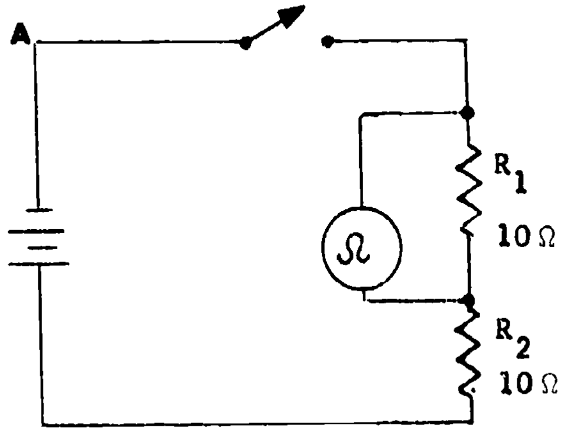
(a. R1, 24Ω $\pm$ 5%; b. R2, 100 KΩ $\pm$ 10%; c. R3, 43 KΩ $\pm$ 5%; d. R4, 200Ω $\pm$ 10%; e. R5, 270Ω $\pm$ 10%)

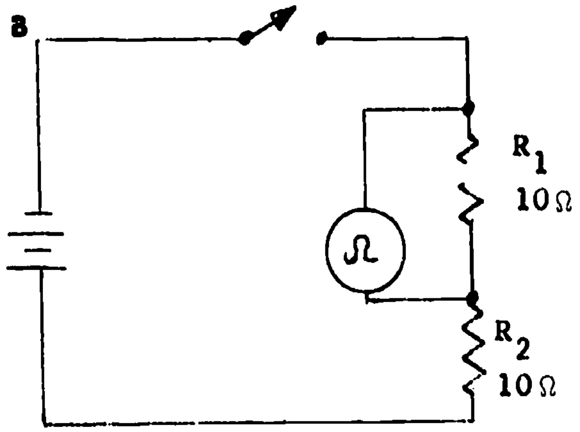
34. An ohmmeter can do more than just measure the value of a resistor. One of the most common and important functions of the ohmmeter is to check circuit continuity. A continuity check can be made to determine if the circuit is properly connected and devices within the circuit have the correct resistance.

(Go to next frame)

35. A continuity check will indicate whether a circuit is: open, which means the conducting path may be broken, poorly soldered, or connected to the wrong terminal. For example, a burned-out light bulb or resistor, or a switch which doesn't make contact, would cause open circuits. In these cases, the meter would indicate infinity (∞).

What would the meter read?



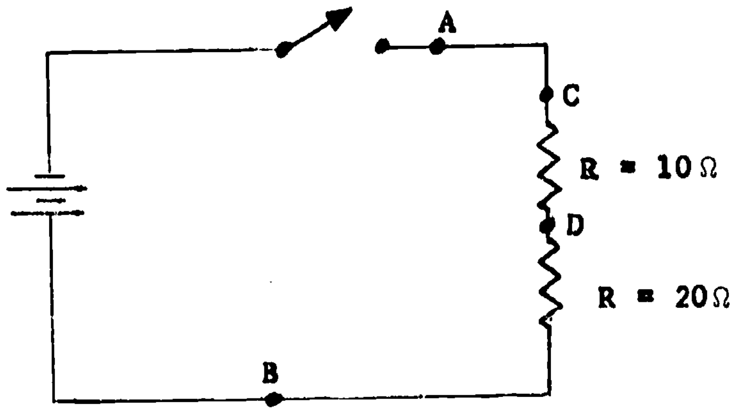


a. (10 ohms); b. (∞ or infinity)

36. To make a continuity check, set the meter as previously explained, then connect the meter in parallel with the circuit or device in question. Often it will be necessary to move the meter leads several times in order to successfully isolate the open or short.

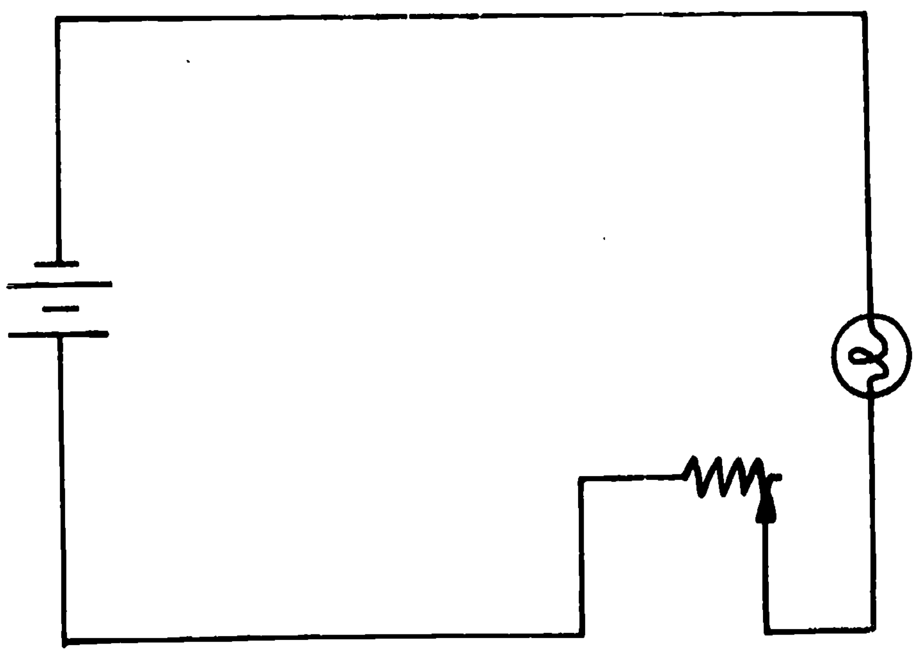
What would the meter indicate if the leads were placed at points:

___ a. A and B
___ b. C and D
___ c. D and B



(a. ∞; b. 10Ω; c. ∞)

37. Using Practice Board 0-1 and the circuit you connected in Lesson II of this module, draw a schematic diagram of the circuit.



38. Again, using Practice Board 0-1 and the circuit you connected in Lesson II, unscrew the lamp to present an open circuit at that point. Since you are going to use an ohmmeter to make continuity checks, what is your next step in readying the circuit?

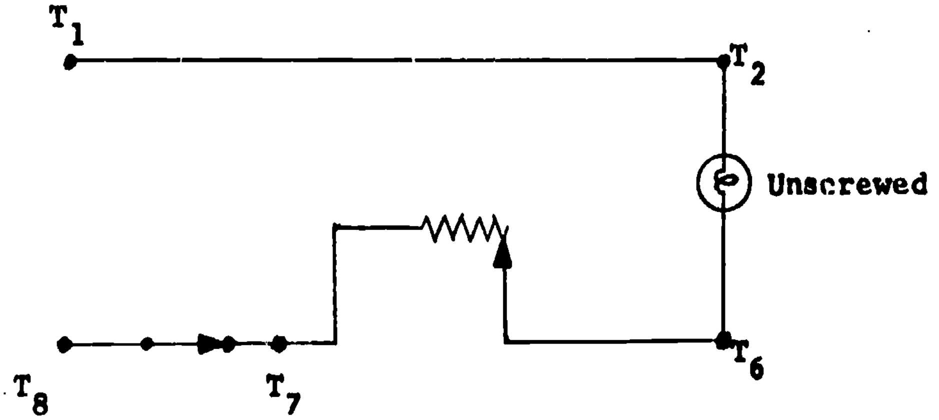
____

____

____

(De-energize the circuit. Do so by disconnecting the battery, or dry cell, from the circuit entirely.)

39. Make sure your switch is closed. Let's take a look at a schematic of the circuit as it looks now:



If your's looks like this, we are ready to proceed. If not, make the necessary corrections now.

(Go to next frame)

40. Set up your multimeter to read resistance and measure the resistance between terminals <u>T1</u> and <u>T8</u>.

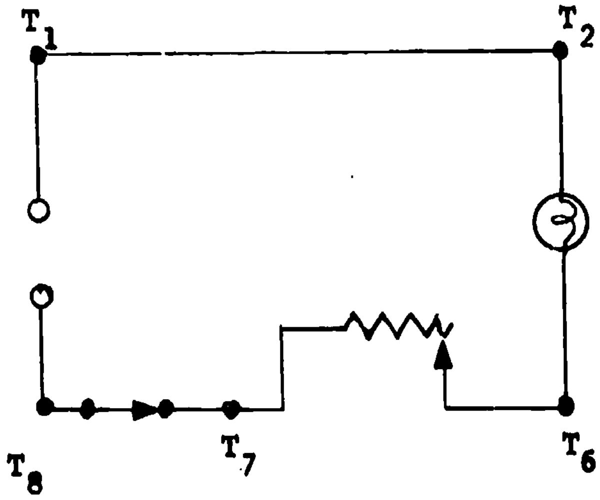
What was your reading? ______________

What does this indicate? ______________________________

____

(∞ The circuit has an open - there is not a complete path for current flow.)

41. So now we know that we have an open in the circuit but -- how to find it? About the best method is to divide the circuit into halves.



You may divide the circuit in any way you wish. We will take the half from T1 to T6 and from T6 to T8. Measure the resistance from T6 to T8.

What was your reading? ______________________
What does this indicate? ______________________

- -

(between 0 - 10, depending on setting of rheostat; there is no open here.)

42. This half of the circuit is eliminated, so you know that the open is somewhere between T1 and T6.

Measure between T1 and T2. ______________ reading.
Measure between T2 and T6. ______________ reading.

Where is your open according to the indicated readings?

- -

(the lamp)

43. Now that you have learned the method for finding an open in a circuit, let's try the same circuit again. This time, screw the lamp back in and open the switch. Using your ohmmeter and a logical procedure, locate the open in the circuit. List the steps you take to find the open, the readings you obtain, and the conclusions that can be drawn from those readings.

STEPS	READINGS	CONCLUSIONS

(THIS IS A TEST FRAME. COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN AT THE TOP OF THE NEXT PAGE.)

ANSWERS - TEST FRAME 43

(There are two possible approaches. If yours is different, you might wish to consult your instructor for confirmation.)

APPROACH ONE

STEPS	READINGS	CONCLUSIONS
Measure T1-T8	∞	There is an open.
Measure T1-T6	Zero (approx.)	This half is good.
Measure T6-T8	∞	The open is located in this half.
Measure T6-T7	0-10 (depending on setting of rheostat)	This component is good
Measure T7-T8	∞	Open switch.

APPROACH TWO

STEPS	READINGS	CONCLUSIONS
Measure T1-T8	∞	There is an open.
Measure T6-T8	∞	Open in this half.
Measure T6-T7	0-10 (depending on setting of rheostat)	This component is good.
Measure T7-T8	∞	Open switch.

- -

IF ANY OF YOUR ANSWERS IS INCORRECT, GO BACK TO FRAME 24 AND TAKE THE PROGRAMMED SEQUENCE.

IF YOUR ANSWERS ARE CORRECT, YOU MAY TAKE THE PROGRESS CHECK, OR YOU MAY STUDY ANY OF THE OTHER RESOURCES LISTED. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL THE QUESTIONS CORRECTLY, YOU HAVE MASTERED THE MATERIAL AND ARE READY TO TAKE THE MODULE TEST. SEE YOUR INSTRUCTOR.

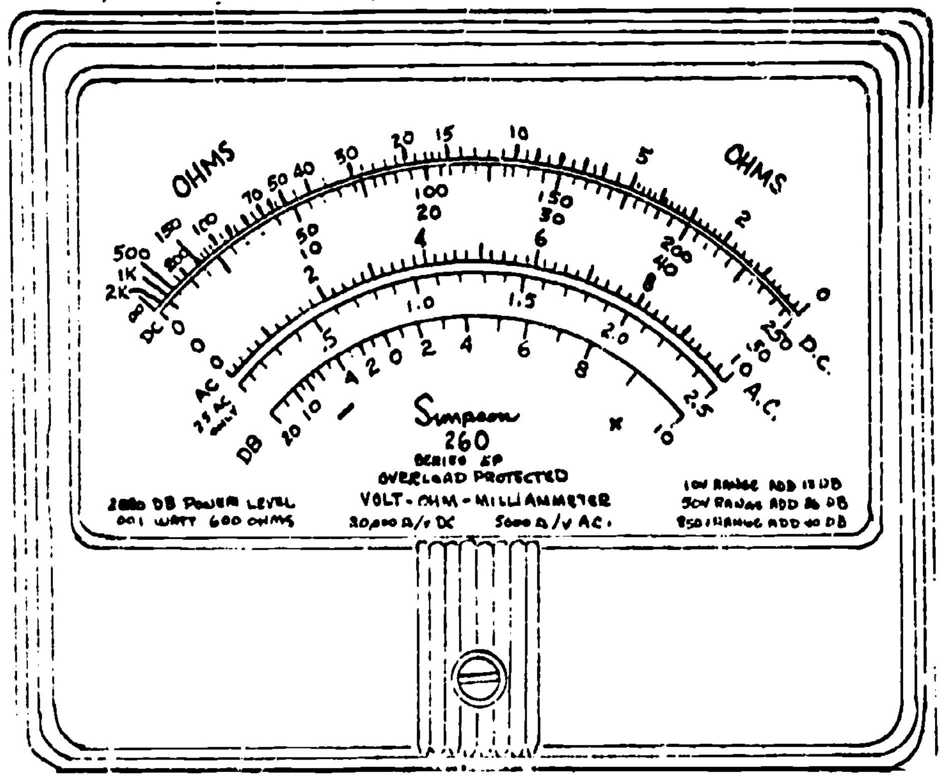
IF YOU DECIDE NOT TO TAKE THE PROGRESS CHECK AT THIS TIME, OR IF YOU MISSED ONE OR MORE QUESTIONS, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU HAVE ANSWERED ALL THE PROGRESS CHECK QUESTIONS CORRECTLY. THEN SEE YOUR INSTRUCTOR AND ASK TO TAKE THE MODULE TEST.

BEST COPY AVAILABLE

SUMMARY
LESSON IV

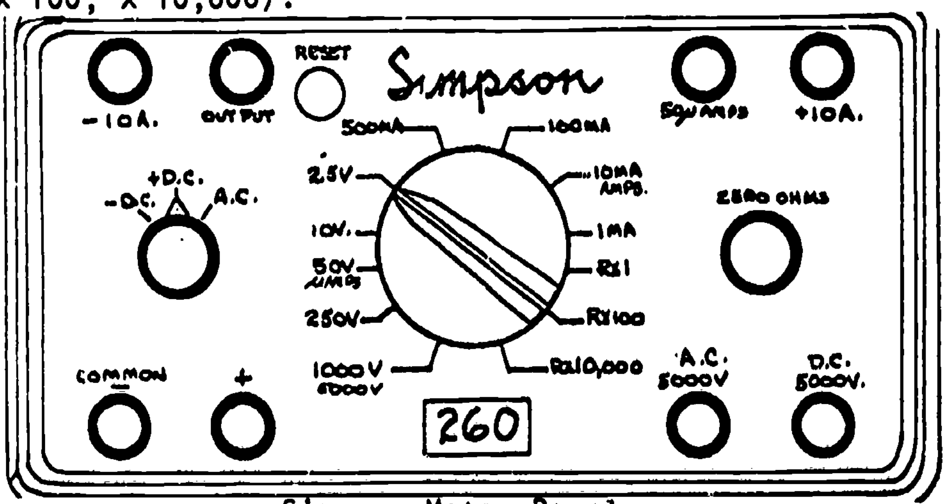
The Ohmmeter

Resistance is measured with an ohmmeter, schematically represented like this: —(Ω)— . To reduce the amount of equipment a repairman must carry, the ohmmeter is normally combined with a voltmeter and an ammeter to make up a <u>multimeter</u> (sometimes called a <u>volt-ohm-milliammeter</u> or <u>VOM</u>). In the rest of this course you will be using the Simpson model 260-5P multimeter to measure circuit values.



The ohmmeter section of the Simpson 260-5P has three ranges: R x 1, R x 100, and R x 10,000. These scales can be used to measure resistances from about 0 to 200 ohms, 20 to 20,000 ohms, and 2,000 to 2,000,000 ohms.

Resistance values are read on the top scale of the meter and the value indicated there is multiplied by the range switch setting (x 1, x 100, x 10,000).



Simpson Meter Panel

When you use the ohmmeter, there are several rules to remember to make accurate readings without endangering yourself or the equipment. These are:

1. Always take your readings from a position directly in front of the meter.

2. "Zero" the meter each time you change the range switch.

3. Never connect an ohmmeter to a circuit which has voltage present.

You may perform the "Ohmmeter Experiment" in Narrative IV if you feel certain you are qualified; if not, continue into Lesson IV.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK, OR YOU MAY STUDY THE LESSON NARRATIVE OR THE PROGRAMMED INSTRUCTION OR BOTH. IF YOU TAKE THE PROGRESS CHECK AND ANSWER ALL OF THE QUESTIONS CORRECTLY, YOU HAVE MASTERED THE MATERIAL AND ARE READY TO TAKE THE MODULE TEST. SEE YOUR INSTRUCTOR.

IF YOU DECIDE NOT TO TAKE THE PROGRESS CHECK AT THIS TIME, OR IF YOU MISSED ONE OR MORE QUESTIONS, STUDY ANY METHOD OF INSTRUCTION YOU WISH UNTIL YOU HAVE ANSWERED ALL THE PROGRESS CHECK QUESTIONS CORRECTLY. THEN SEE YOUR INSTRUCTOR AND ASK TO TAKE THE MODULE TEST.